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REMOTE SENSING STUDY-LAS VEGAS WASH BASIN, LAS VEGAS, NEVADA

National Field Investigations Center
Denver, Colorado

August 1972

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ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF ENFORCEMENT

REMOTE SENSING STUDY

LAS VEGAS WASH BASIN
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U S Department of Commerce
Springfield VA 22151

National Field Investigations Center-Denver
Denver, Colorado

Region IX
San Francisco, California

August 1972

Details of illustrations in this document may be better studied on microfiche.

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February 1972

I. INTRODUCTION

An aerial remote sensing program, requested by EPA, Region IX, was completed in late January 1972 over the Las Vegas Wash Basin. The boundaries of the area studied are McCarran Airport on the west, Henderson, Nevada, on the south, Lake Mead on the east, and the Rainbow Gardens area on the north. This is shown in Figure 1.

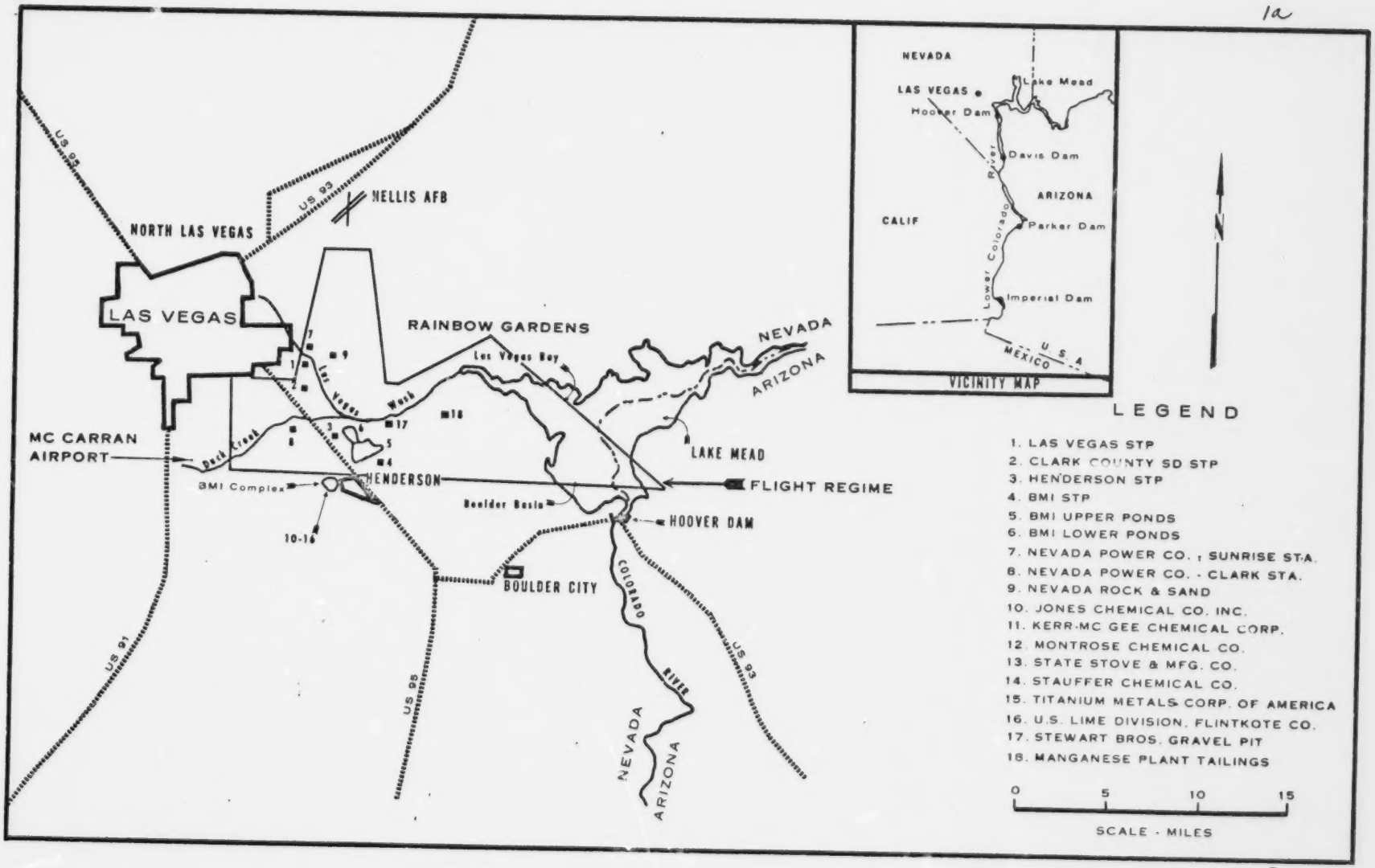


Figure 1. Location Map - Las Vegas

II. SUMMARY AND CONCLUSIONS

The ground-water seepage from the BMI Upper and Lower Ponds has been established. The ground-water behavior patterns in the BMI pond area, as postulated by the Desert Research Institute (DRI), University of Nevada, Las Vegas, have been confirmed.

The actual discharge locations for the following facilities have been pinpointed and weighed as to overall impact upon water flowing in the Las Vegas Wash:

i) Las Vegas STP
ii) Clark County SD STP
iii) Nevada Power Company - Sunrise Station
iv) Nevada Power Company - Clark Station
v) Nevada Rock and Sand Company
vi) BMI Industrial Complex
vii) Stewart Bros. Gravel Pit
viii) Manganese Plant Tailings

It can be concluded that, as long as the Henderson STP continues to discharge into the BMI Lower Ponds, seepage, carrying away the deposited metals, minerals, nutrients, etc., will continue from the ponds to the Wash indefinitely due to the recharge of the near surface aquifer.

The BMI Upper Ponds will continue to seep wastes to the Las Vegas Wash as long as waste water is present in them or until they are lined so as to prevent the seepage.

The Stewart Bros. Gravel Pit acts as a ground-water drain for seepage from the BMI Upper Ponds, in addition to other ground-water sources.

The abandoned manganese mine tailings piles, located east of the BMI Upper Ponds, have been leaching into the Las Vegas Wash for an extended period of time.

III. RECOMMENDATIONS

It is recommended that the Las Vegas Wash be surveyed from the air a minimum of once each 6 months in order to document the behavior of the BMI Ponds and the other municipal/industrial waste discharges.

It is recommended herein that the recommendations of Section III of the report entitled *Pollution Affecting Las Vegas Wash, Lake Mead, and the Lower Colorado River, Nevada-Arizona-California,* dated December 1971, Environmental Protection Agency, Office of Enforcement, Division of Field Investigations, Denver Center, be implemented at an early date. A brief outline of these recommendations is as follows:

(1) Municipal, sanitary, and industrial wastewaters be collected, treated, and discharged through a regional waste management system.

(2) Industrial process wastewaters, boiler blowdown water, cooling system blowdown water, and other highly mineralized wastes be segregated from cooling water and evaporated in impermeable ponds with no discharge.

(3) Once-through cooling water systems either be connected to recirculating systems, or the cooling water be discharged to surface water following treatment as required.

(4) Groundwater in the near-surface aquifer, lying under and down-gradient from the BMI Ponds, be recovered by BMI through installation and operation of a pumping system with pumpage to be disposed through evaporation in impermeable ponds or by other adequate means.

(5) Reports on progress in implementing recommended pollution abatement measures be submitted to the State of Nevada and EPA.

Additionally, it is recommended that Remote Sensing, which can be effectively used to monitor the behavior of the near-surface aquifer in the vicinity of the BMI Ponds as well as throughout the Las Vegas Valley, be utilized to monitor the progress of the abatement plan instituted.

IV. MISSION PURPOSE

The aerial reconnaissance program was designed to fulfill the following objectives:

(a) Establish the presence of and discharge patterns for the pollutant seepage from the Basic Management, Incorporated, (BMI) holding ponds into the Wash.

(b) Establish the presence of industrial/municipal wastes entering the Wash in addition to the BMI discharges.

(c) Locate and document all locations where groundwater (sub-surface) is surfacing within a close proximity to the Wash.

(d) Locate and document the actual channel (water flow) path through the Wash from approximately the Duck Creek influent to Las Vegas Bay (western section of lower Lake Mead).

V. BACKGROUND/HISTORICAL INFORMATION

Concern over the deterioration of the water quality throughout the Las Vegas Wash Basin led to formal studies and investigations as far back as 1961 and extended through 1968. The focal point of these studies was the behavior of the Basic Management, Incorporated, (BMI) holding ponds. In 1961, a study concluded that groundwater return flows, originating in the holding ponds, caused water quality degradation in the Wash.[1]

In May 1966, the Federal Water Pollution Control Administration carried out a water quality survey of the Las Vegas Wash and the

Las Vegas Bay area of Lake Mead. The effort did not yield proof that wastewater from the BMI ponds was seeping into the Las Vegas Wash.

An investigation, carried out in July 1968, offered only probabilities for the source of mineral wastes found in the Wash water.

A study made in December 1968 was successful in isolating and defining the overall water quality control problem within the Las Vegas Wash. However, this effort did not establish the presence/behavior patterns of the leakage or seepage from the BMI Ponds.

An extensive effort, carried out for EPA by the Desert Research Institute, University of Nevada, was initiated in 1970 in order to define the affects of the BMI Ponds upon the hydrogeologic characteristics and water quality of the lower Las Vegas Wash. An interim progress report was released in November 1971.[1]

VI. RELATED INFORMATION[2]

Las Vegas Wash, an intrastate tributary of the Colorado River, drains Las Vegas Valley and the Las Vegas, Nevada, metropolitan area. The Wash is an intermittent stream except for the lower 11 miles reaching from the metropolitan area to Lake Mead. A majority of the perennial streamflow in this reach consists of municipal and industrial waste discharges. Water quality in the Wash is characterized by high dissolved solids concentrations and excessive levels of nitrogen and phosphorus which stimulate algal growths.

Las Vegas Bay is an arm of the Boulder Basin area of Lake Mead. Las Vegas Wash enters the Bay at its western extremity as shown in Figure 1. The Bay is heavily utilized for water-based recreation including water contact sports. The nutrients discharged by the Wash have produced high nitrogen and phosphorus levels in much of Las Vegas Bay. Excessive algal growths have occurred, producing a distinct green color in the Bay, accompanied by odors and nuisance conditions. Algal masses 20-25 times greater than background levels in other areas of Lake Mead have been measured in the Bay. These conditions reduce the recreational value of the Bay and interfere with beneficial water uses. Studies have shown that Lake Mead downstream from Las Vegas Bay and the Colorado River below Hoover Dam have a higher algal growth potential than Lake Mead upstream from Las Vegas Bay, indicating that the nutrients discharged by Las Vegas Wash may also be affecting these waters.

The City of Las Vegas secondary waste treatment plant is discharging approximately 21 million gallons per day (mgd) of treated municipal wastes, through a short outfall ditch, into the Las Vegas Wash. This effluent is a major source of dissolved solids and algal nutrients contributing 52.4, 68.4, and 22.8 percent, respectively, of the known municipal and industrial discharges of nitrogen, phosphorus, and dissolved solids to the Wash. The effluent provides about half of the total flow discharged through the Las Vegas Wash into Lake Mead.

The Clark County Sanitation District discharges about 10 mgd of treated municipal effluent from its secondary waste treatment plant through a mile-long outfall ditch into Las Vegas Wash. This effluent is also a major source of dissolved solids and algal nutrients, contributing 29.0, 31.4, and 15.0 percent, respectively, of the nitrogen, phosphorus and dissolved solids known to be entering the Wash from municipal and industrial sources. The effluent contributes about one-fourth of the average flow in the Wash.

The Nevada Power Company discharges cooling tower blowdown water, averaging about 0.9 mgd from two steam electric generating stations, into the Las Vegas Wash. These discharges are sources of dissolved solids and nitrogen. Clark Station discharges about 0.7 mgd to Duck Creek about three miles above its confluence with the Wash. Nitrogen and dissolved solids loads discharged are about 1.2 and 4.1 percent, respectively, of known municipal and industrial discharges of these substances. Sunrise Station discharges about 0.2 mgd of blowdown water directly to Las Vegas Wash. This effluent contains about 0.5 and 1.1 percent, respectively, of known nitrogen and dissolved solids discharges. The former receives its cooling water from the Clark County Sanitation District and the latter from the City of Las Vegas STP.

Nevada Rock and Sand Company discharges about 0.5 mgd of wastewater from an asphalt hot mix plant to a small tributary of Las Vegas Wash. This waste discharge contributes about 0.4 and 0.2 percent, respectively, of nitrogen and dissolved solids loads discharged to Las Vegas Wash by known municipal and industrial sources.

BMI operates a waste disposal system that includes a secondary type domestic sewage treatment plant and a large complex of waste disposal ponds covering an area of more than 1,300 acres. About 250 acres of the ponds are presently in use. The ponds receive approximately 2 mgd of inadequately treated domestic wastes from the City of Henderson municipal plant and the BMI sewage treatment plant. The ponds also receive approximately 9 mgd of untreated industrial wastes. Sources of industrial waste include Kerr-McGee Chemical Corporation; Jones Chemical Company, Incorporated; Montrose Chemical Corporation; State Stove and Manufacturing Company; Stauffer Chemical Company; Titanium Metals Corporation of America; and U. S. Lime Division - Flintkote Company. Characteristics of the industrial wastes, being discharged to the BMI Ponds, are highly variable, ranging from relatively uncontaminated cooling water to highly deleterious wastes. Dissolved solids concentrations as high as 200,000 mg/1, a pH range from 2 to 13, and nitrate concentrations as high as 300 mg/1 have been observed in the combined waste stream. Since the disposal ponds are unlined, these wastes percolate into the near-surface aquifer underlying the ponds and enter Las Vegas Wash as groundwater seepage.[2] This seepage presently averages more than 5 mgd and is a major source of dissolved solids and nitrates. Although the seepage contributes only 13 percent of the total flow in the Wash, it contributes 16.4 and 56.8 percent, respectively, of the nitrogen and dissolved solids loads discharged to the Wash by municipal and industrial sources.

Long-term seepage of industrial wastes from the BMI waste disposal ponds and from waste ponds and conveyance channels in the BMI industrial complex area has resulted in the development of an artificially elevated groundwater mound in the near-surface aquifer. This groundwater is highly contaminated with industrial wastes. Dissolved solids concentrations exceeding 20,000 mg/l and nitrate concentrations exceeding 150 mg/l have been measured. The highly contamined groundwater enters the Las Vegas Wash in the form of seepage. Owing to the presence of the groundwater mound and the natural gradient of the water table, contaminated groundwater seepage would continue for several years even after all artifical recharge of the near-surface aquifer was stopped. This seepage could be prevented and residual industrial wastes in the groundwater system recovered by the operation of a shallow well system along Las Vegas Wash to intercept aquifer outflow. Disposal of recovered wastes by evaporation in impermeable impoundments would be required to prevent return waste flow to the Colorado River system. Elimination of the seepage would substantially reduce the dissolved solids and nitrates loads discharged through the Las Vegas Wash into Lake Mead. Table VI-1 summarizes the waste loads being discharged into the Las Vegas Wash.

VII. CHRONOLOGICAL DATA

The chronological details of the flight program are given as follows:

(a) 27 October 1971 - Time over target of 1030-1200 hours PST in which the Basin was covered photographically by

TABLE VI-I

SUMMARY OF NITROGEN, PHOSPHORUS AND DISSOLVED SOLIDS LOADS
DISCHARGED TO LAS VEGAS WASH BY MUNICIPAL AND INDUSTRIAL WASTE SOURCES

Source	Flow		Nitrogen Load		Phosphorus Load		Total Dissolved Solids Load	
	mgd	Percent	lb/day as N	Percent	lb/day as P	Percent	lb/day	Percent
City of Las Vegas Sewage Treatment Plant	21	56.2	3,530	52.4	1,940	68.4	120,000	22.8
Clark County SD Sewage Treatment Plant	10	26.7	1,950	29.0	890	31.4	79,000	15.0
Nevada Rock and Sand Company	0.5	1.3	30	0.4	-	-	1,000	0.2
Nevada Power Company Clark Generating Station	0.7	1.9	80	1.2	2	0.1	21,000	4.1
Nevada Power Company Sunrise Generating Station	0.2	0.5	37	0.5	5	0.1	6,000	1.1
Basic Management, Inc. Waste Disposal Pond Seepage	5	13.4	1,100	16.4	-	-	300,000	56.8
Total	37.4	100.0	6,727	100.0	2,837	100.0	527,700	100.0

three 70mm framing cameras. There was no Infrared Line Scanner on board the aircraft for this mission.

Flight Altitude - 4,000 feet MSL.

(b) 2 December 1971 - Time over target of 1330-1415 hours PST. The Las Vegas Wash was covered by the Infrared Line Scanner. No photographic coverage was obtained.

(c) 13 January 1972 - Time over target of 1400-1440 hours PST in which the Basin was covered by the Infrared Line Scanner. No photographic coverage was obtained.

Flight Altitude - 6,000 feet MSL.

(d) 19 January 1972 - Time over target of 1000-1400 hours PST in which the total flight regime was covered.

Flight Altitude - 4,500 feet MSL (above mean sea level, barometric) for the photographic work, and 2,000 to 2,300 feet MSL for Infrared Line Scanner* data recording.

VIII. AIRCRAFT SENSOR DATA

The reconnaissance data were recorded aboard an RF-4B high performance aircraft, with the exception of the 27 October 1971 flight. This aircraft contained three framing cameras and an Infrared Line Scanner (IRLS). All cameras were mounted in the tri-vertical array, i.e., mounted in their respective vertical positions coincident with the nadir of the aircraft. Each of the cameras was uploaded with different film/optical filter combinations. They were capable of recording the presence of optical energy within the following bands of the optical spectrum:

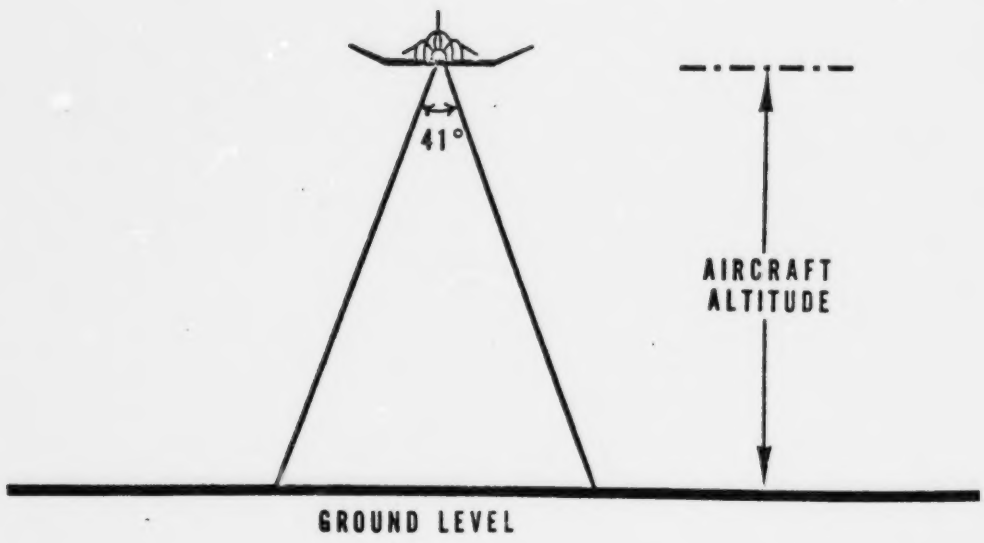
* This equipment is explained in the Aircraft Sensor Data Section.

(a) Near ultraviolet, resulting in a 4.5" x 4.5" negative- Kodak 2403 recording film with a Wratten 47A gelatin optical filter. This film/filter combination has an effective bandwidth of 0.2 microns from 0.34 to 0.54 microns (ultraviolet to deep blue).

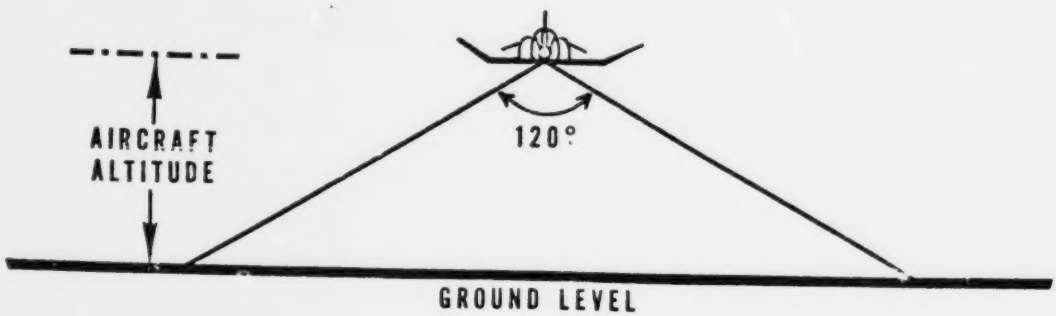
(b) Visible region of the optical spectrum, resulting in a true color 4.5" x 4.5" positive aerographic ektrachrome transparency - Kodak SO-397 aerographic ektrachrome film with a Wratten HF-3/HF-5 optical filter combination. The film/filter combination has an effective bandwidth of 0.3 microns from 0.4 to 0.7 microns (blue to red).

(c) Near infrared region of the optical spectrum which was overlapped with a portion of the visible spectrum (red, orange), resulting in an aerographic ektrachome 4.5" x 4.5" false color (rendition) transparency - Kodak 2443 aerographic film with a Wratten 16 gelatin optical filter. The film/filter combination has an effective bandwidth of 0.38 microns from 0.52 microns to 0.90 microns (orange to near infrared).

This viewing angle of each camera was 41° about the aircraft's nadir as shown below.



The IRLS is a cryogenic device (optical and electronic) capable of detecting passive electromagnetic energy resulting from target thermal emissions in the infrared band from 8 to 14 microns (1 micron equals 10^{-6} meters). It has a cross-track scan angle of 120° about the aircraft's nadir, as shown below



The true color photographic technique served as a real-world color basis for the photo interpretation of the imagery obtained during this mission.

The ultraviolet/near infrared photographic media and the IRLS provided further refinements in the positive detection, location, and identification of pond seepage, surfacing of ground or sub-surface water, small bodies of water located within the Wash Basin, and the actual water channel through the Las Vegas Wash from a point near the mouth of Duck Creek to Las Vegas Bay, forming a part of Lake Mead. The false color infrared film was used for the location and identification of shrouded or masked waterways (due to color likeness or foliage cover) and provided detailed information regarding biological growth detection and identification.

The IRLS was the most effective sensor used during these missions.

IX. DESCRIPTION OF DATA REDUCTIONS

The interpretations of the airborne reconnaissance data are presented in the following paragraphs:

A. Basic Management, Incorporated (BMI) Holding Ponds

There are two groups of holding ponds within the BMI complex commonly named the Upper Ponds and the Lower Ponds. They are located in the area between Henderson, Nevada, and the Las Vegas Wash on the east side of Highway 95. The ponds are sketched in Figure 2. There are seven sources of industrial waste that discharge into this pond complex. The identity of the respective companies are given in Tables IX-1 and IX-2. The pertinent data regarding these two groups of ponds are discussed separately in the following paragraphs:

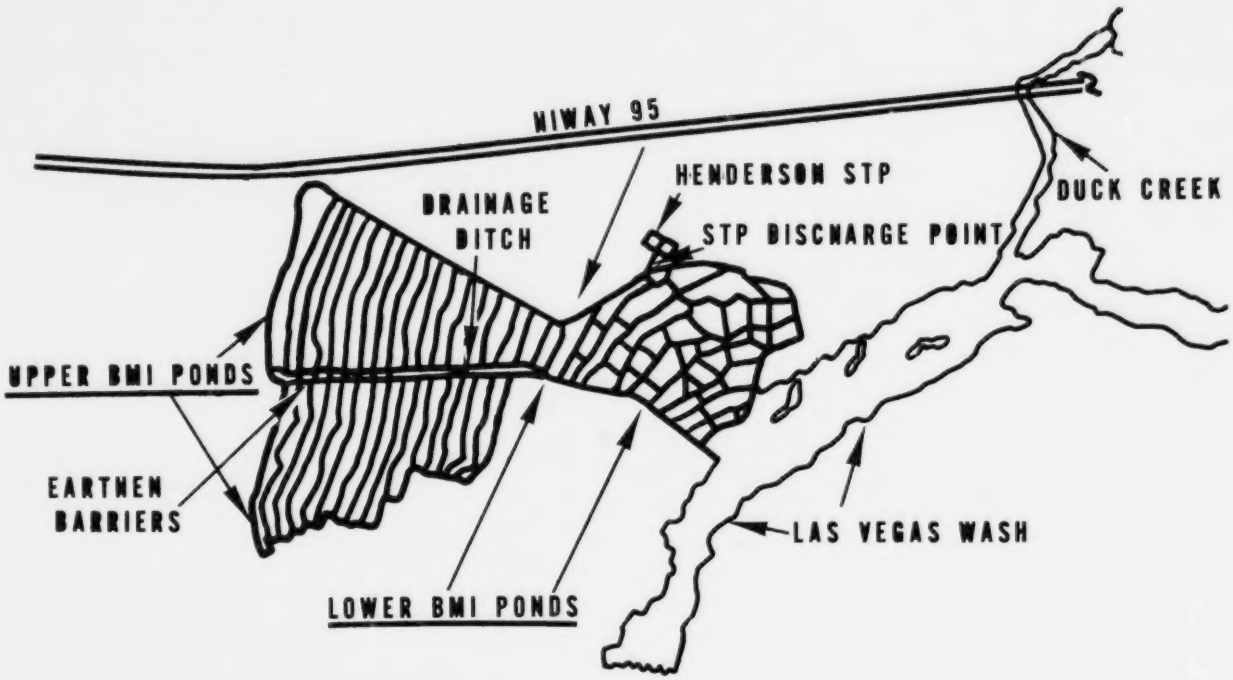


Figure 2 Basic Management,INC Holding Ponds

TABLE IX-1

SUMMARY OF INDUSTRIAL WASTE SOURCES
DISCHARGING TO BMI

Industry	Industry Type	Waste Volume mgd	Waste Type	Waste Characteristics	Treatment	Disposal	Remarks
Basic Management, Inc.	1/	1.53	Sanitary	Normal Sewage	Secondary (High rate Trickling Filter)	BMI Upper Ponds	Includes 1.0 mgd municipal wastes from Henderson.
		8.92	Mixed Industrial Cooling & Process wastes.	pH range 2-13 High TDS and NO_3	None	BMI Upper Ponds	Seepage from ponds enters Las Vegas Wash.
Jones Chemical Co.	Industrial Chemicals (SIC 281)	< 0.001	Process	Unknown	None	BMI Upper Ponds	Evaporation system to be completed in 1972.
Kerr-McGee Chemical Corp.	Industrial Inorganic Chemicals (SIC 2819)	0.03	Sanitary	Normal Sewage	BMI STP	BMI Upper Ponds	
		0.30	Cooling & Boiler Blowdown	Normal Sewage	None	BMI Upper Ponds	
		0.35	Process	High TDS	None	BMI Upper Ponds	
State Stove and Manufacturing Co.	Manufacture Water Heaters (SIC 3639)	< 0.001	Cooling & Process	High TDS	None	BMI Upper Ponds	Batch dump 35,000 gallons per month.
Stauffer Chemical Co. (Incl. Montrose Chemical Corp.)	Industrial Inorganic & Organic Chemicals (SIC 281, 2879)	0.34	Sanitary	Normal Sewage	BMI STP	BMI Upper Ponds	
		3.50	Cooling & Boiler	--	None	BMI Upper Ponds 2/	
		0.70	Process	High pH & TDS	None	BMI Upper Ponds 2/	
Titanium Metals Corp. of America	Produce Titanium Ingots (SIC 3356)	0.16	Sanitary	Normal Sewage	BMI STP	BMI Upper Ponds	
		3.59	Cooling	-	None	BMI Upper Ponds	
		0.40	Process	Low pH, High NO_3	None	BMI Upper Ponds	Recycling or evaporation under study.
U. S. Lime Division Flintkote Co.	Hydrated Lime (SIC 2819)	0.06	Cooling & Dust Control	High Solids	None -	BMI Upper Ponds	

1/ Basic Management, Inc. operates a sewage treatment plant and waste disposal ponds for sanitary and industrial wastes from Jones Chemical Co., Kerr-McGee Chemical Corp., Montrose Chemical Corp., State Stove and Manufacturing Co., Stauffer Chemical Co., Titanium Metals Corp. of America, and U. S. Lime Division-Flintkote Co.

2/ Prior to January 1971, these wastes were discharged to the BMI lower ponds.

TABLE IX-2

SUMMARY OF MUNICIPAL WASTE SOURCES
DISCHARGING TO BMI

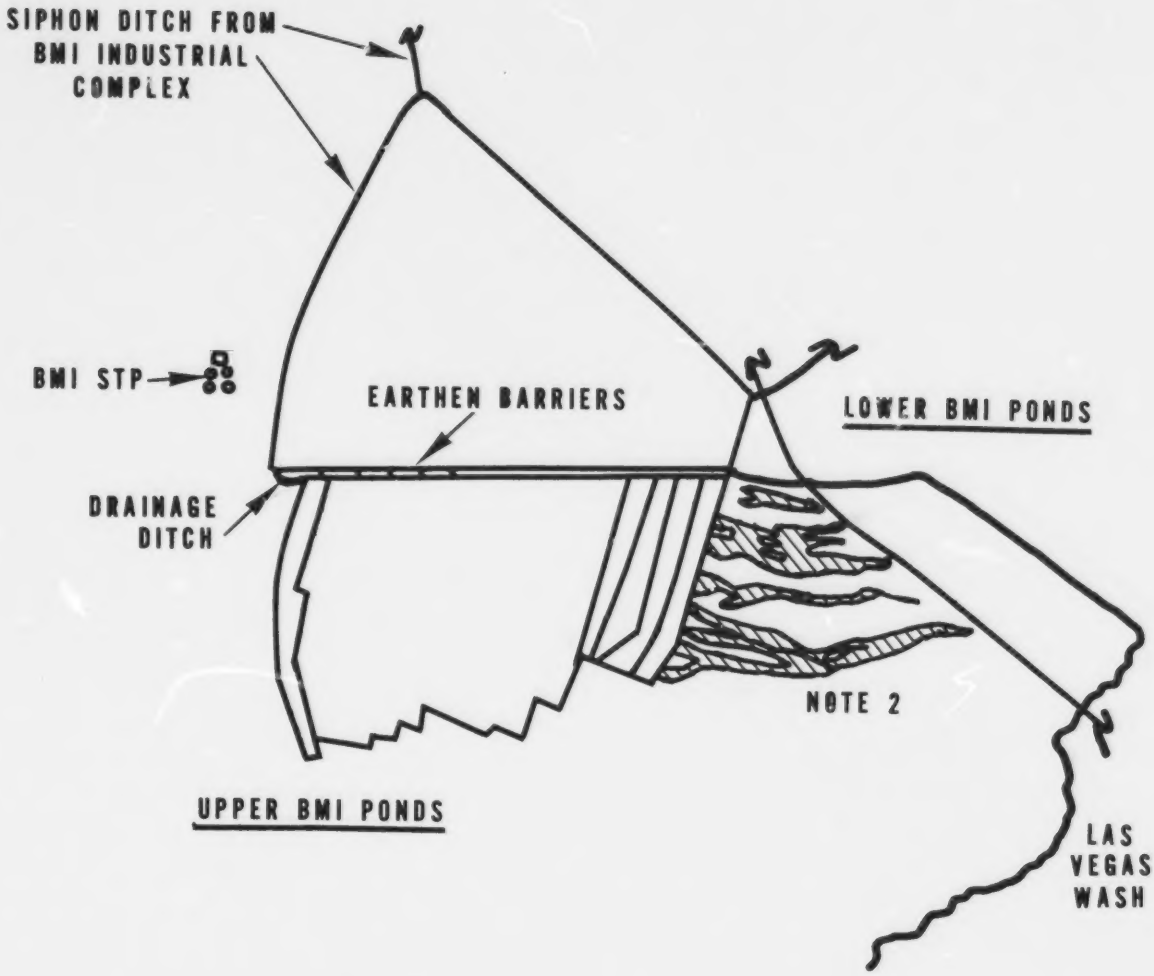
Source	Population Served	Plant Influent mgd	Treatment Processes	Plant Effluent mgd	Effluent Disposal	Remarks
City of Henderson	18,000	1.0	Imhoff Tanks and oxidation ponds	0.8	BMI Lower Ponds	Pond seepage reaches Las Vegas Wash
		1.0	No Treatment	1.0	BMI Sewage Treatment Plant	Half of Henderson municipal waste treated by BMI. See Table IX-1.

1. BMI Upper Ponds

The thermal and false color infrared imagery indicated that seepage has occurred from the eastern-most half of the Upper Ponds for an extended period of time. There were lines of foliage, identified as salt cedar (a phreatophyte) from ground truth data, leading from the ponds toward the Wash. The presence of this growth in turn establishes the presence of groundwater at a shallow depth, containing the nutrients required to sustain this growth. The soil in this area does not contain sufficient nutrients to sustain this growth with only water provided. The location of the foliage with respect to the Upper Ponds is sketched in Figure 3.

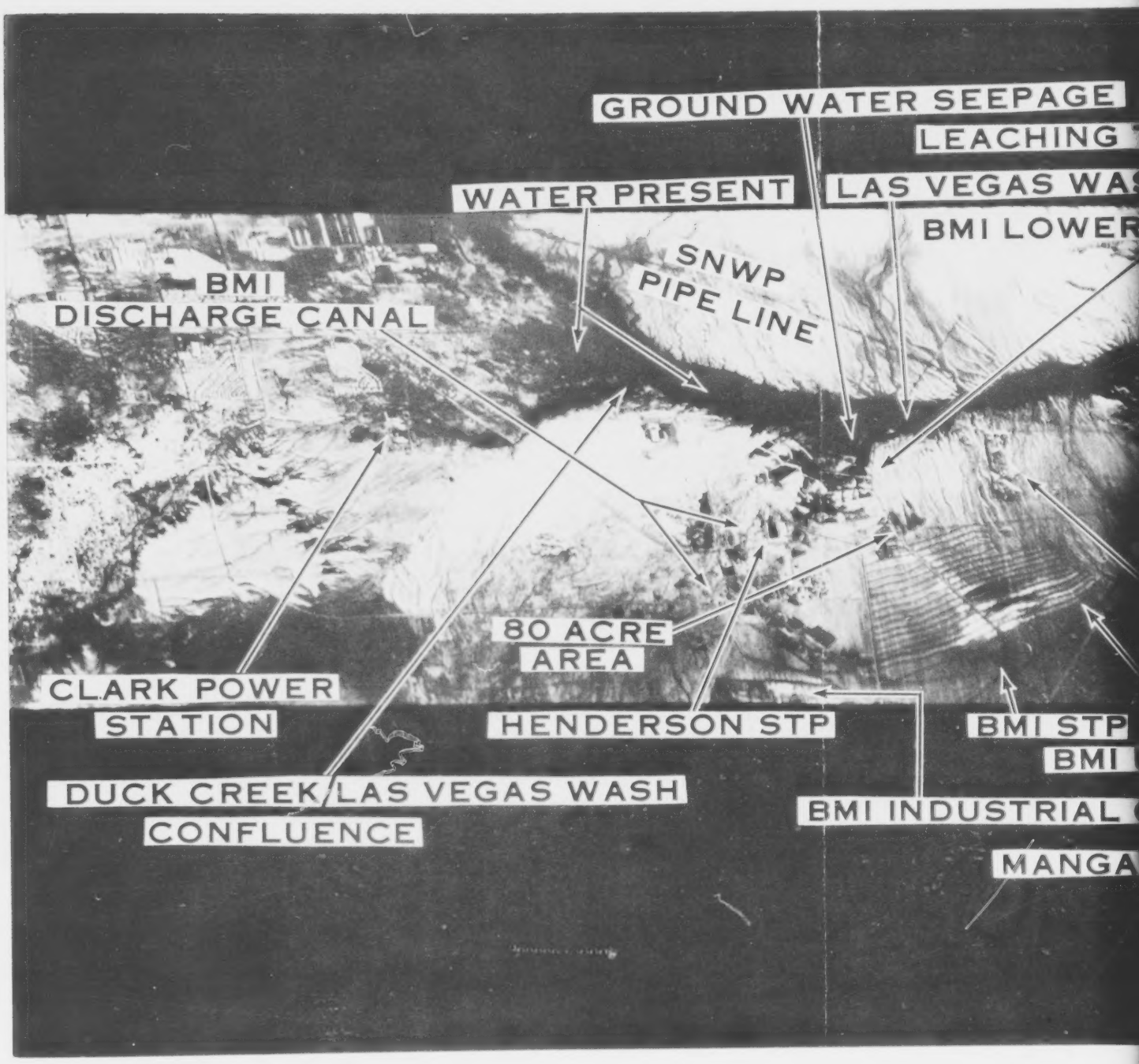
It is significant to note that aerial photographs, taken in the early 1940's prior to the use of the ponds, show that the phreatophytes were not present. Considering the nature and characteristics of the foliage confirms the presence of the shallow groundwater mound discussed above.

The thermal imagery from the 2 December 1971 and the 13 January 1972 missions indicates the presence of surface or near-surface water seepage, from the above mentioned section of this complex, over an 80-acre area. This is indicated in Figures 4, 6, and 7. There was more water present in this 80-acre area during the former mission [Figures 4 and 5] than during the latter [Figures 6 and 7].



1) CROSS-HATCHED AREAS REPRESENTS FOLIAGE
2) FALSE COLOR INFRARED AND IRLS IMAGERY INDICATED NEAR SURFACE MOISTURE IN THIS AREA

Figure 3 Foliage Growth Near BMI Upper Ponds


GROUND WATER SEEPAGE
LEACHING
WATER PRESENT
LAS VEGAS WA
BMI LOWER
SNWP
PIPE LINE
BMI
DISCHARGE CANAL
80 ACRE
AREA
CLARK POWER
STATION
HENDERSON STP
BMI STP
BMI
DUCK CREEK/LAS VEGAS WASH
CONFLUENCE
BMI INDUSTRIAL
MANGA

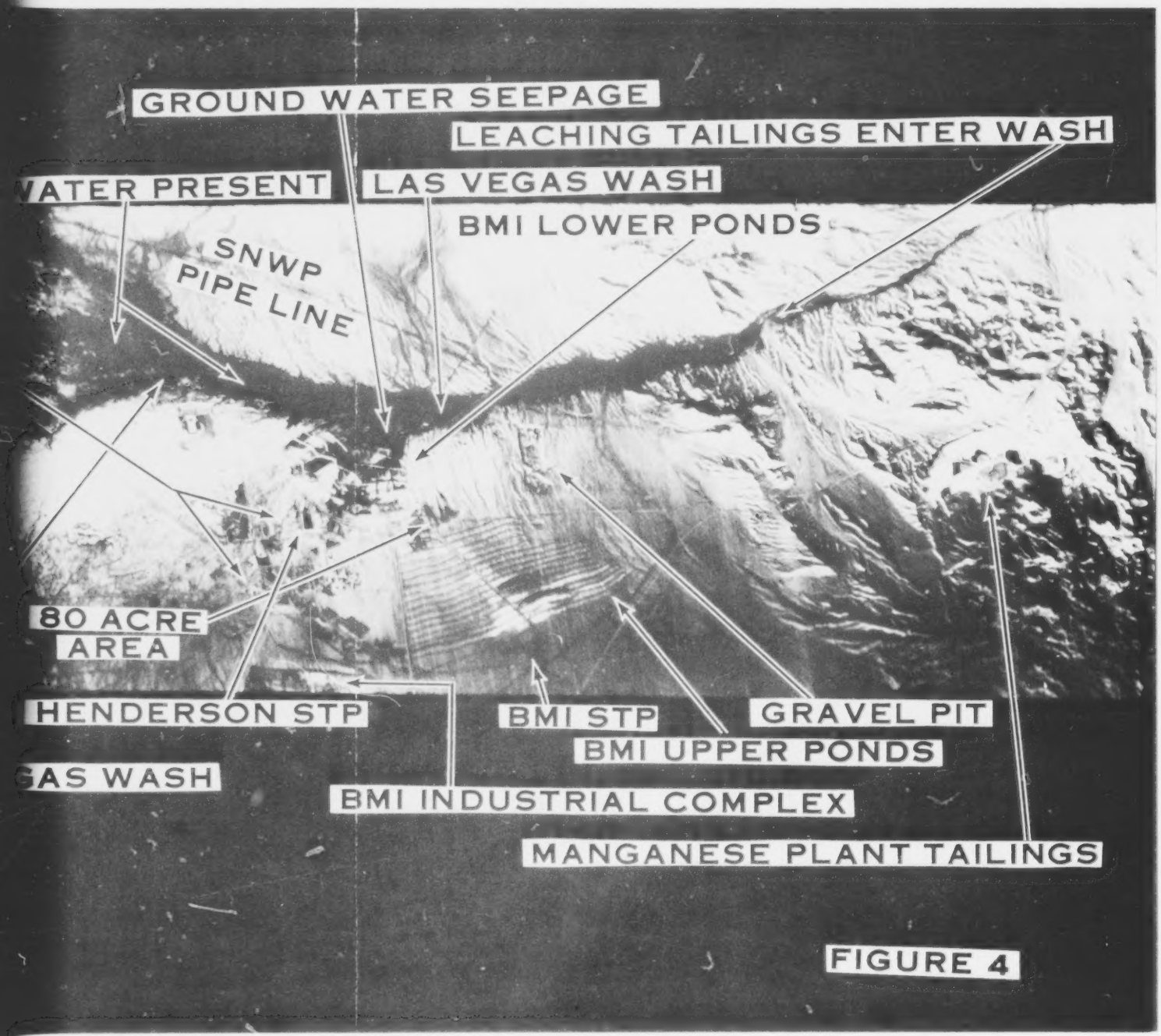
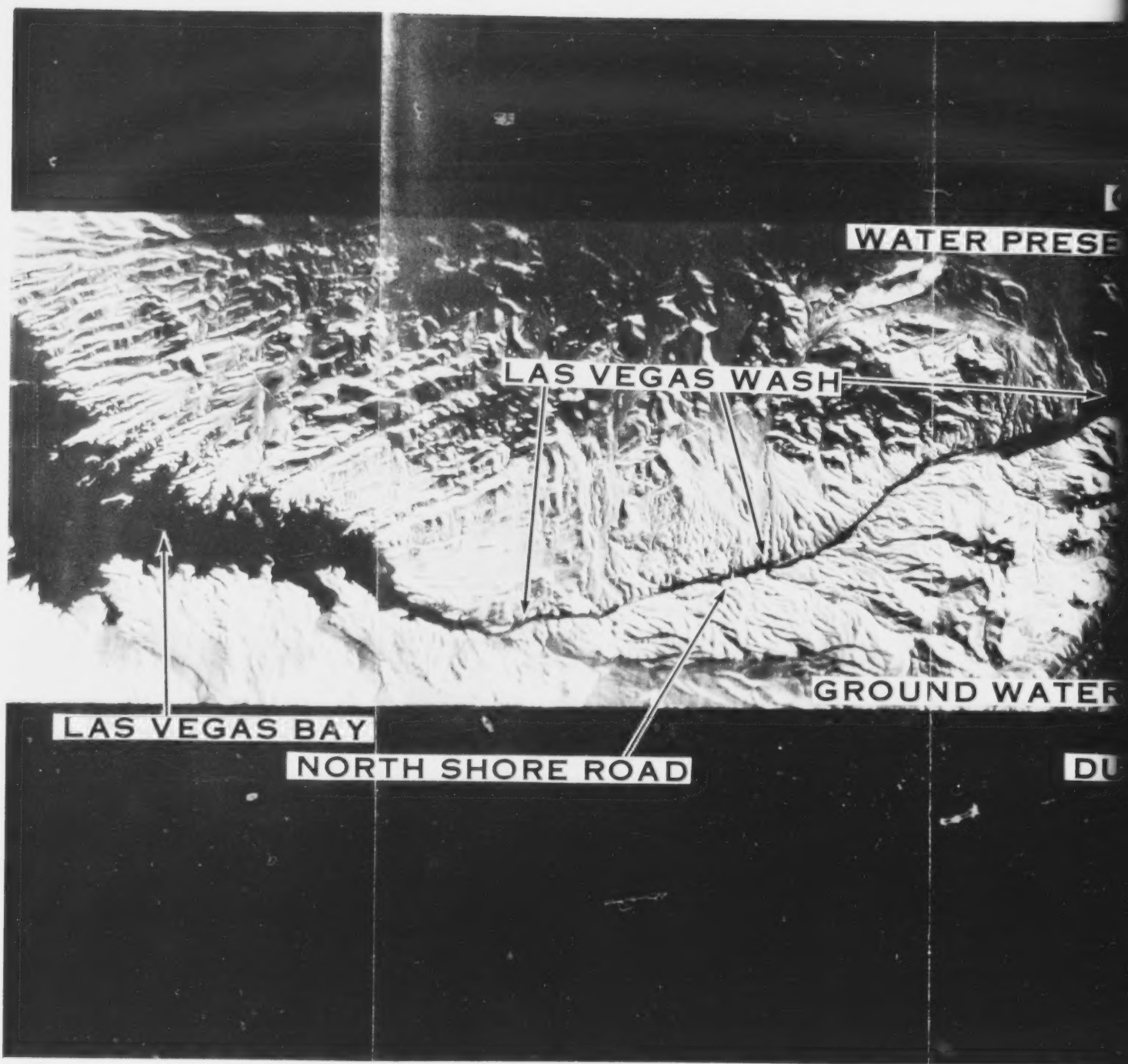


FIGURE 4

Reproduced from
best available copy.


WATER PRESE
LAS VEGAS WASH
GROUND WATER
LAS VEGAS BAY
NORTH SHORE ROAD
DU

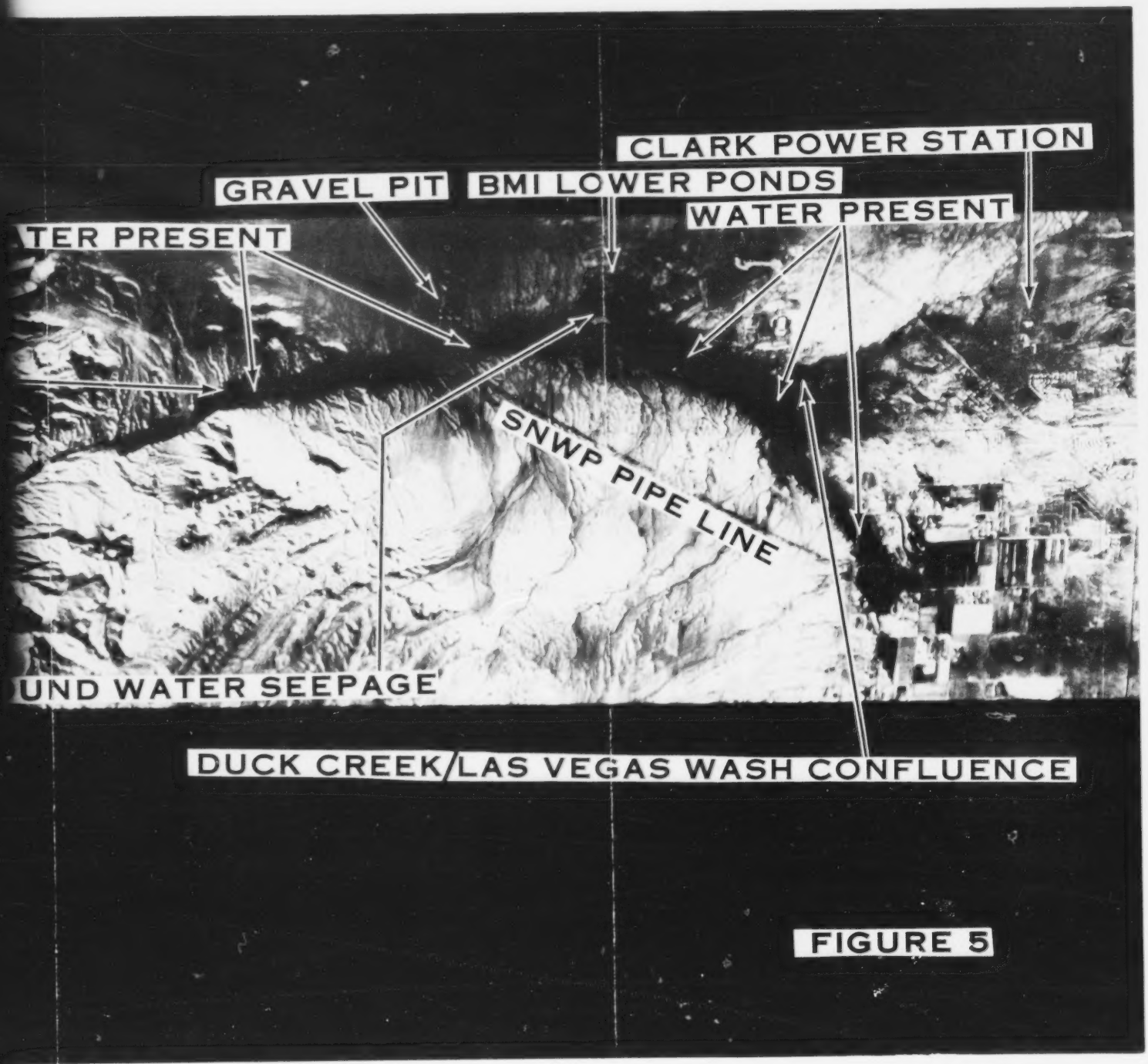
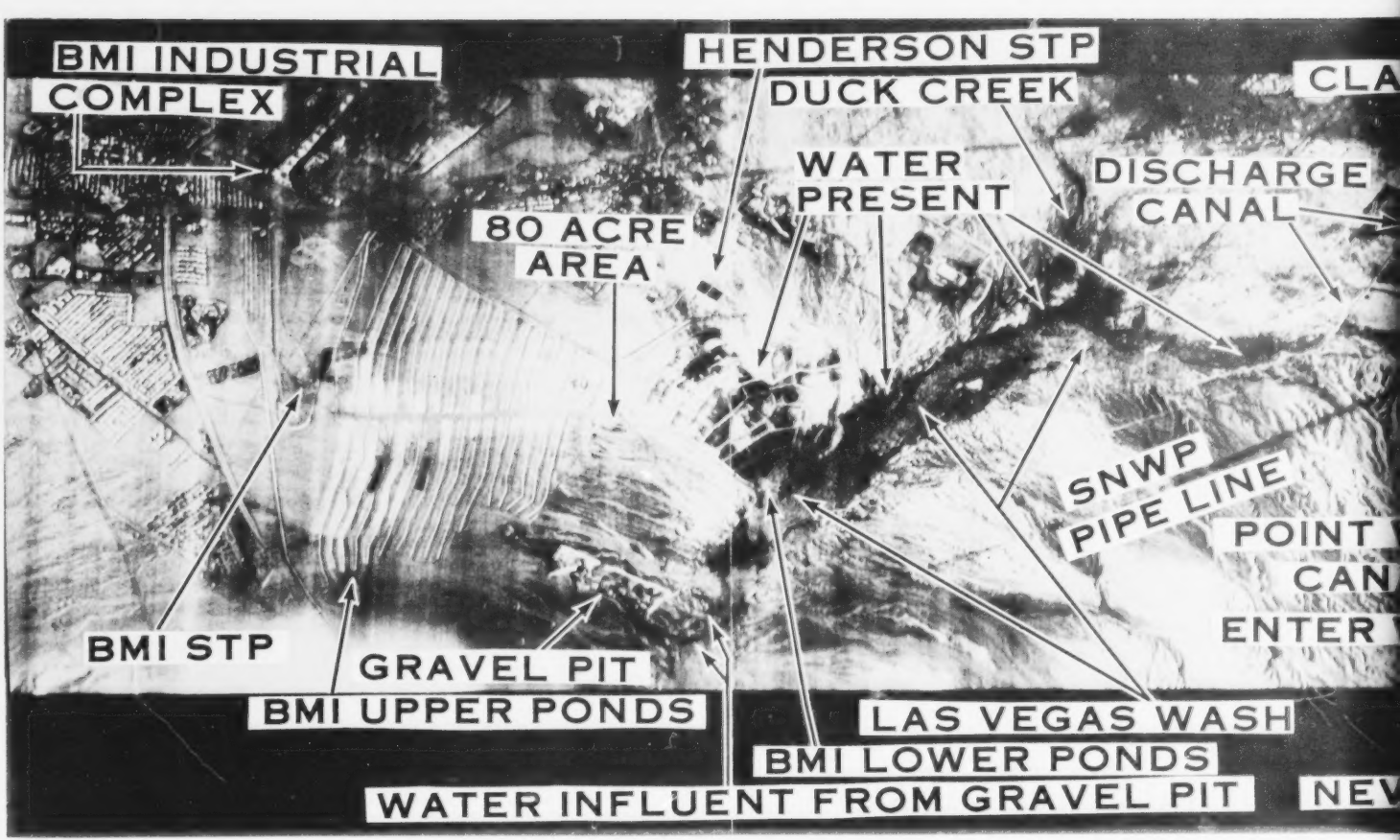

CLARK POWER STATION
GRAVEL PIT
BMI LOWER PONDS
WATER PRESENT
TER PRESENT
SNWP PIPE LINE
UND WATER SEEPAGE
DUCK CREEK/LAS VEGAS WASH CONFLUENCE

FIGURE 5


BMI INDUSTRIAL
COMPLEX
HENDERSON STP
DUCK CREEK
CLA
WATER
PRESENT
DISCHARGE
CANAL
80 ACRE
AREA
SNWP
PIPE LINE
POINT
CAN
ENTER
BMI STP
GRAVEL PIT
BMI UPPER PONDS
LAS VEGAS WASH
BMI LOWER PONDS
WATER INFLUENT FROM GRAVEL PIT
NEV

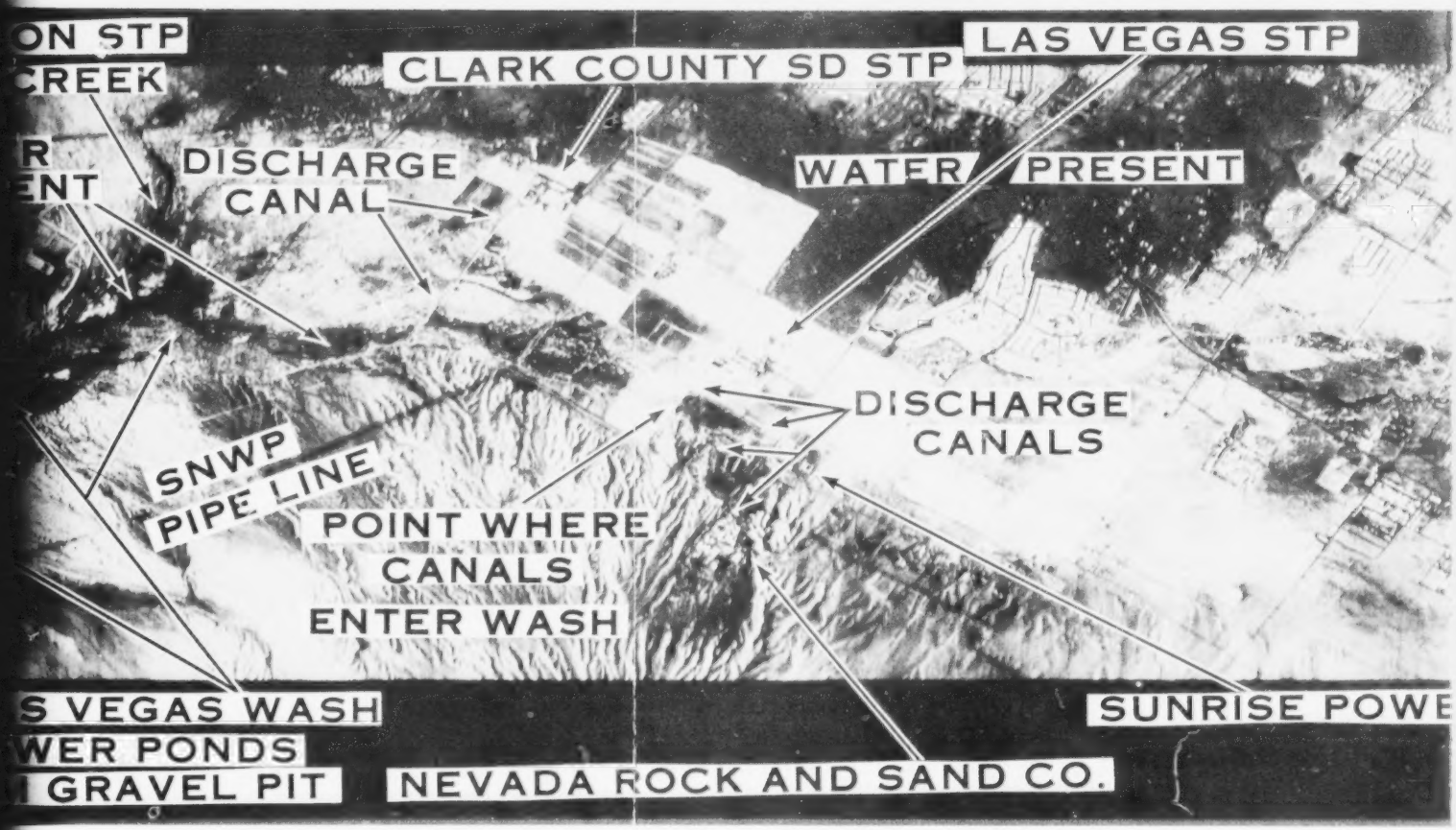
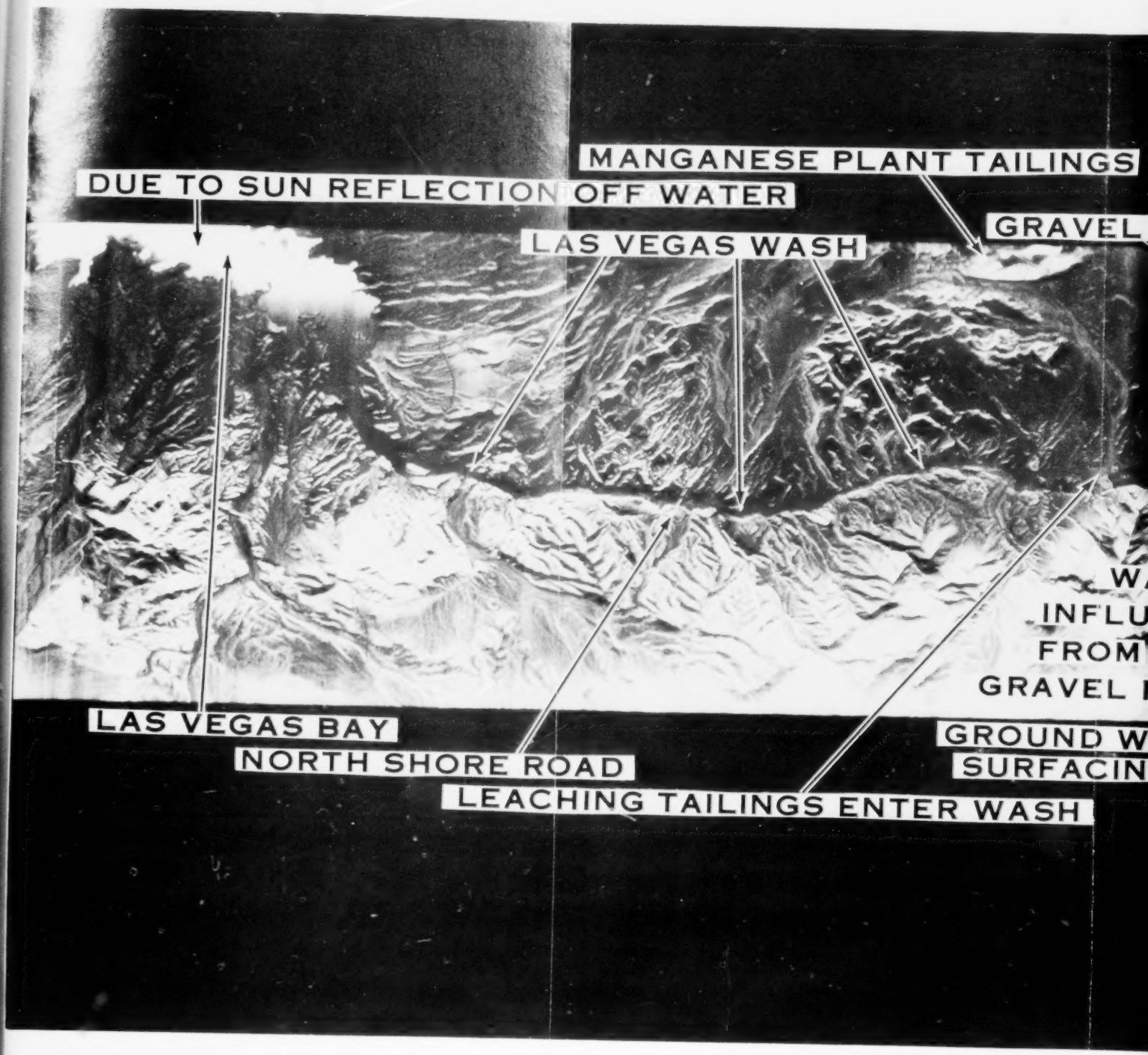
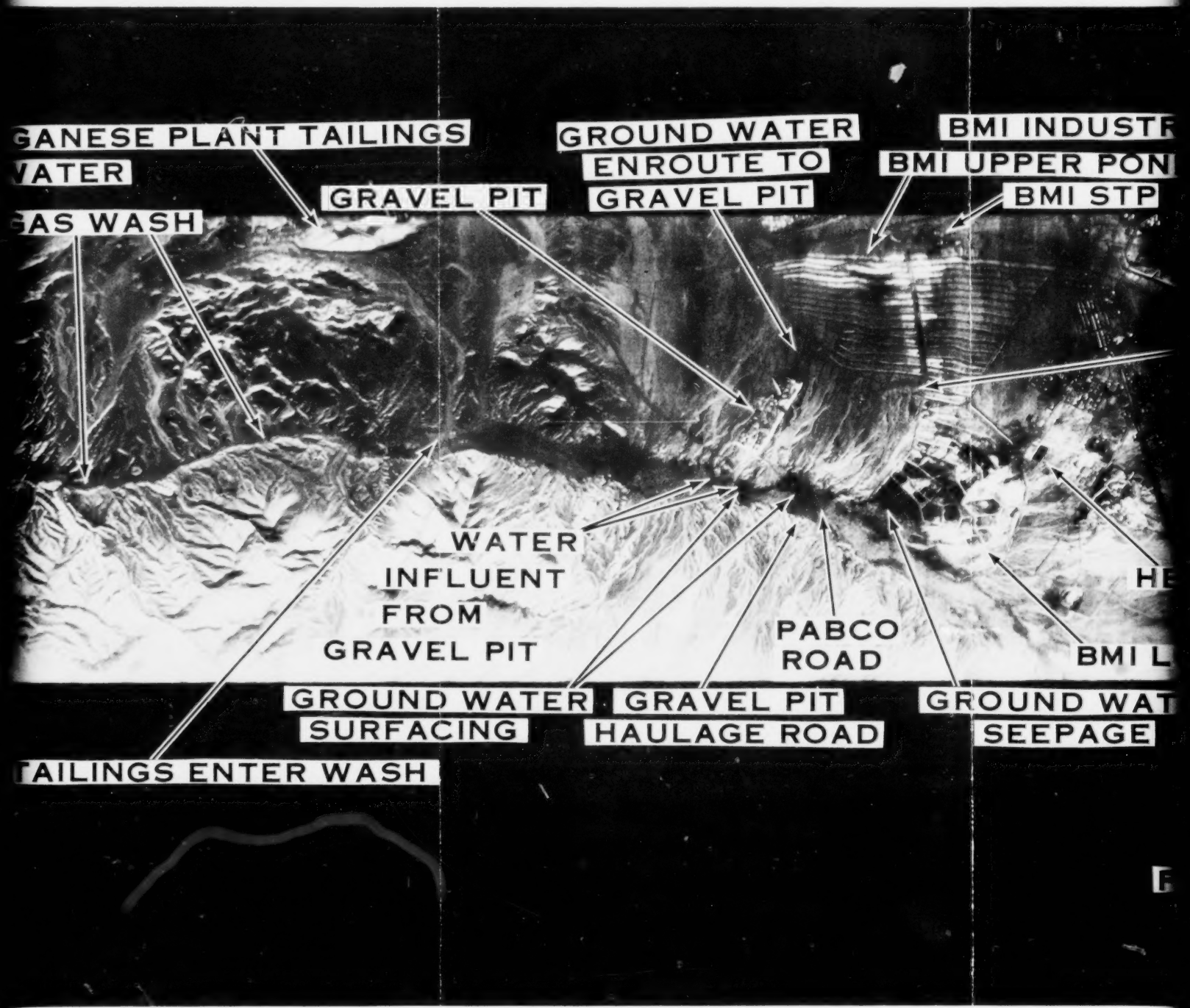

ON STP
CREEK
R
ENT
DISCHARGE
CANAL
CLARK COUNTY SD STP
LAS VEGAS STP
WATER PRESENT
DISCHARGE
CANALS
SNWP
PIPE LINE
POINT WHERE
CANALS
ENTER WASH
S VEGAS WASH
WER PONDS
GRAVEL PIT
NEVADA ROCK AND SAND CO.
SUNRISE POWE

FIGURE 6

Reproduced from best available copy.


MANGANESE PLANT TAILINGS
DUE TO SUN REFLECTION OFF WATER
GRAVEL
LAS VEGAS WASH
W
INFLU
FROM
GRAVEL
LAS VEGAS BAY
GROUND W
NORTH SHORE ROAD
SURFACIN
LEACHING TAILINGS ENTER WASH


GANESE PLANT TAILINGS
VATER
GAS WASH
GRAVEL PIT
GROUND WATER
ENROUTE TO
GRAVEL PIT
BMI INDUSTR
BMI UPPER PON
BMI STP
WATER
INFLUENT
FROM
GRAVEL PIT
PABCO
ROAD
HE
BMI L
GROUND WATER
SURFACING
GRAVEL PIT
HAULAGE ROAD
GROUND WAT
SEEPAGE
TAILINGS ENTER WASH

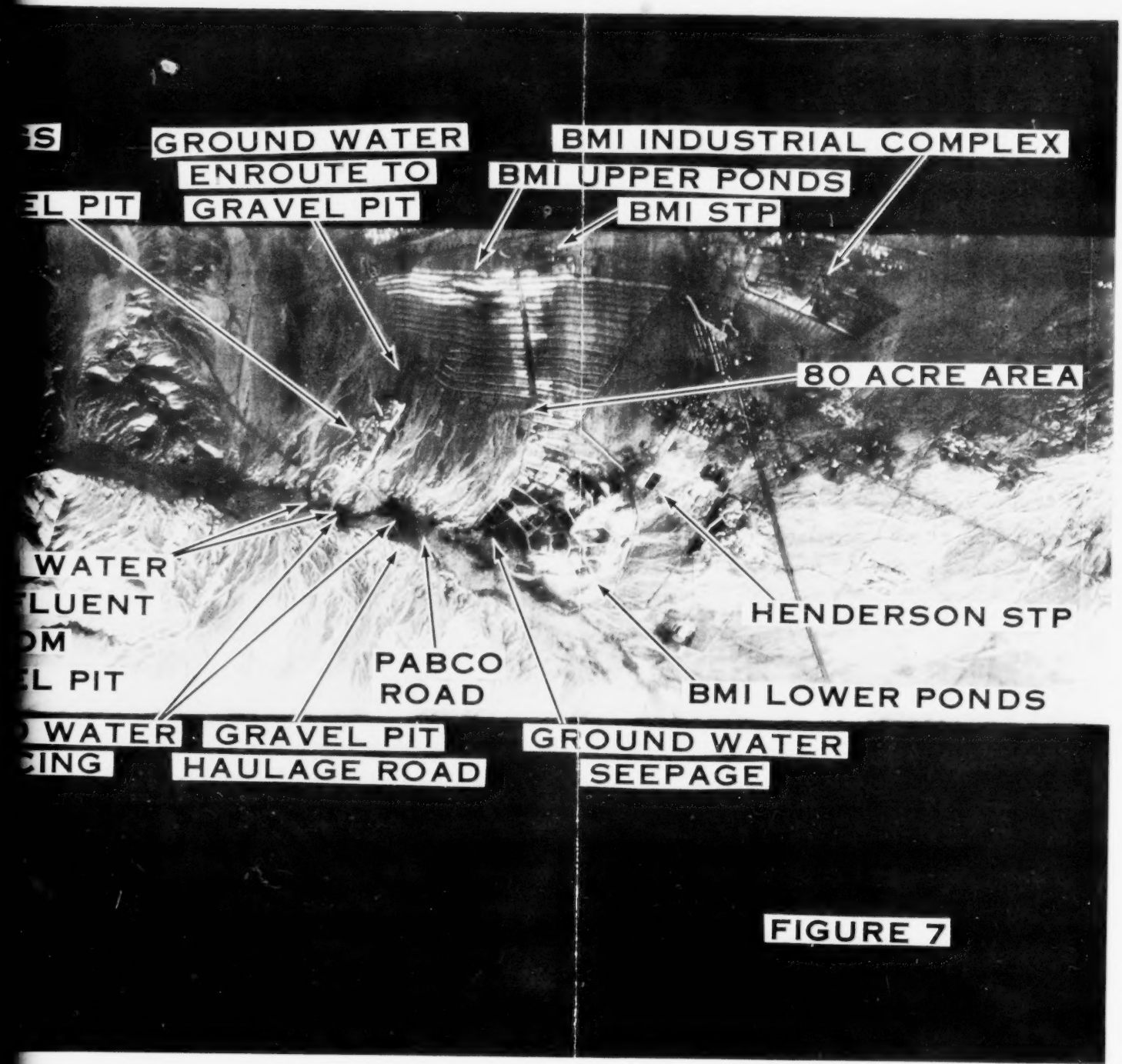

GROUND WATER
ENROUTE TO
GRAVEL PIT
BMI INDUSTRIAL COMPLEX
BMI UPPER PONDS
BMI STP
80 ACRE AREA
HENDERSON STP
PABCO
ROAD
BMI LOWER PONDS
GRAVEL PIT
HAULAGE ROAD
GROUND WATER
SEEPAGE

FIGURE 7

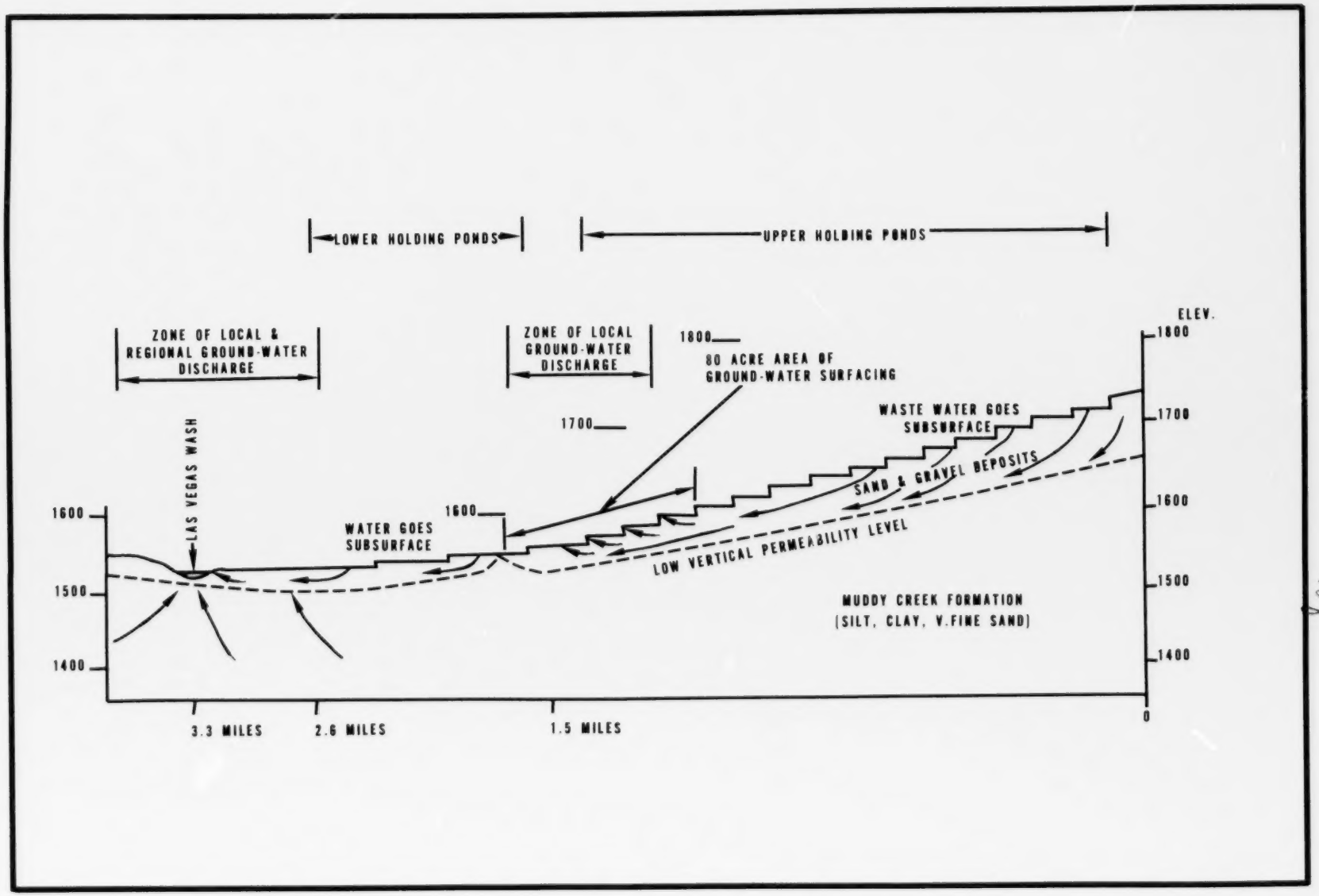


Figure 8. Schematic Ground-Water Flow Diagram-B.M.I. Holding Ponds

At the respective times of flight, there was no direct surface water flow from the Upper Ponds into the Wash. The thermal and the false-color infrared imagery did indicate the presence of near-surface moisture in the soil of the general area reaching from the above mentioned seepage area to the Wash as shown in Figures 3, 4, 6, and 7. This establishes the fact that groundwater discharge, from the BMI Upper Ponds, moves through the sub-surface and subsequently surfaces in the above-mentioned 80-acre area as a result of low vertical permeability of the soil. A schematic of the groundwater flow is given in Figure 8. The water again enters the sub-surface medium on the northern edge (edge closest to the Wash) of the 80-acre area and finally surfaces within the Wash where it enters the flowing stream between Pabco Road and the Las Vegas Valley Lateral, as shown in Figure 9. The imagery does confirm the movement of groundwater in this localized area, as postulated by the Desert Research Institute.[1]

In conclusion, any wastewater, being discharged into the BMI Upper Ponds by the industrial/municipal waste sources given in Tables IX-1 and IX-2, will seep to the Las Vegas Wash and subsequently into Lake Mead. This has been established by a continuous water path through the Wash as shown in Figures 5 and 7.

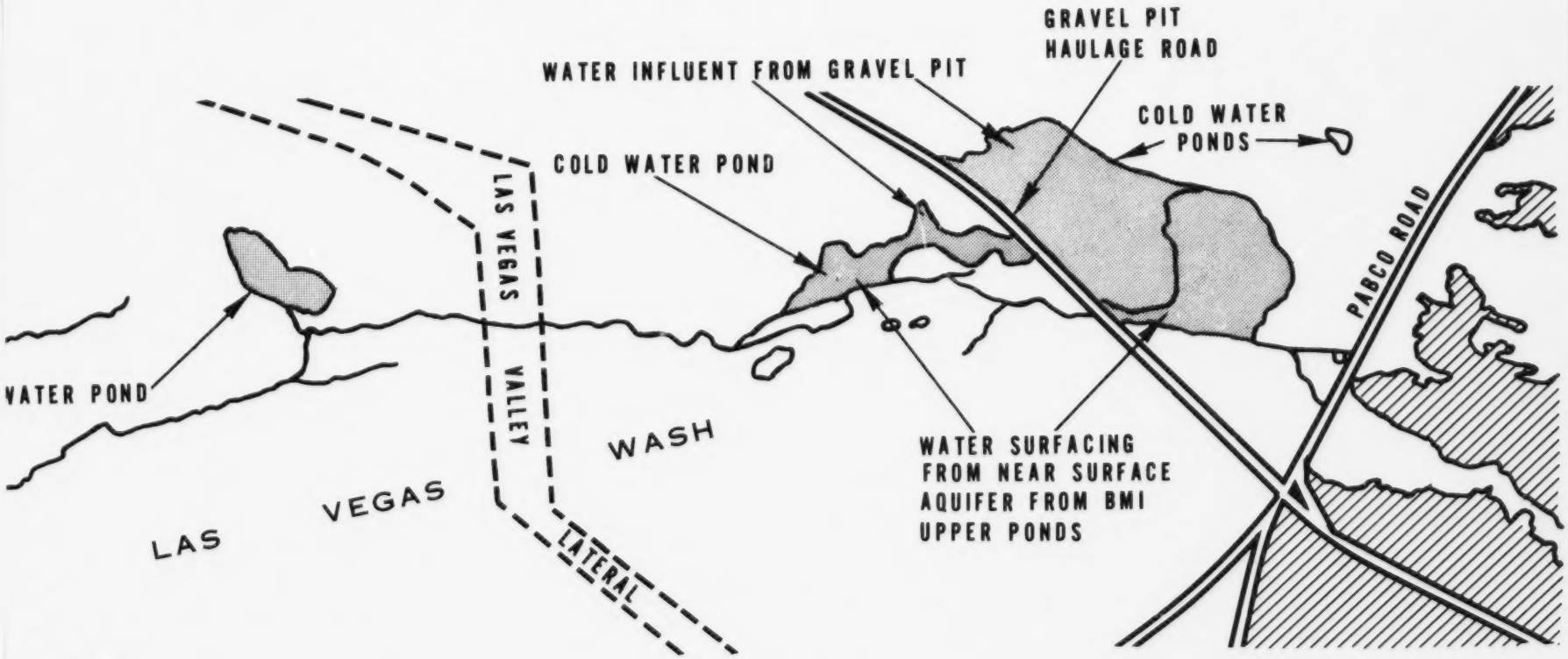


Figure 9. Ground Water Resurfacing Locations from BMI Upper Ponds

During the time of ground truth data collection in the area from the BMI Upper Ponds to the Wash, nearly 50 percent of the soil surface, especially in the above mentioned 80-acre area, was soaked with oil. There was also a pesticide odor in this area. Likewise, in the area of the siphon ditch, located at the upper end of the BMI Upper Ponds as shown in Figure 3, the pesticide odor was extremely strong. Small slicks of oil were floating on the water in this ditch enroute to the Upper Ponds. The presence of oil in the soil, mentioned above, can be easily explained with the use of the Ground Water Schematic in Figure 8. The oil, used in the manufacture of pesticides according to information received from DRI, was discharged into the Upper Ponds. It followed the sub-surface route shown in Figure 8 and resurfaced in the 80-acre area nearly saturating the ambient soils. Patches of oil-laden soil were traced to the Wash, indicating that these wastes are entering that stream of water.

2. BMI Lower Ponds

Seepage from the BMI Lower Ponds into the Las Vegas Wash was present during each mission. The greatest amount of seepage occurred during the 2 December 1971 mission which is represented by Figures 4 and 5. During this time period, industrial wastes were being discharged into the BMI Lower

Ponds from the BMI industrial complex through an open ditch. This ditch entered the ponds at a point on their western-most boundary which would be the far left side of the ponds shown in Figure 4. The imagery definitely shows that these wastes were seeping directly to the Wash immediately upstream from Pabco Road. In addition to the aforementioned wastes, the Henderson sewage treatment plant was discharging domestic wastes from two oxidation ponds into the BMI Lower Ponds. The discharge point is along the western side of the upper reaches of this section of ponds as shown in Figure 2. The domestic waste was also seeping through the domain of the BMI Lower Ponds into the Las Vegas Wash.

According to reports received, all industrial waste discharges into the BMI Lower Ponds ceased as of 1 January 1972. The imagery, obtained from the 13 January 1972 mission, shows the western-most sections of the Lower Ponds complex containing a significantly less amount of surface/near-surface water than was observed during the 2 December 1971 mission. However, the Henderson sewage treatment plant waste discharge was nearly identical during these two missions. In the latter mission, the seepage from the BMI Lower Ponds into the Wash was nearly equal to that observed during the former mission. Likewise, the imagery from the 19 January 1972 mission shows that the pond seepage was present and nearly identical in magnitude to that observed in the above-mentioned previous missions. The detailed seepage patterns of the ground-water

from the BMI Lower Ponds to the Las Vegas Wash, are shown in Figure 10 and its associated transparent overlay. The clear areas of the transparency depict the presence of surface/near-surface water at the time of flight on 19 January 1972 while the cross-batched areas depict dry areas.

In conclusion, although the industrial waste discharge has been removed from the BMI Lower Ponds, they continue to seep into the Wash with the Henderson sewage treatment plant discharge being the only external contributor of water. The actual seepage from the ponds has not ceased or decreased significantly. Finally, as long as the Henderson sewage treatment plant continues to discharge wastewater into these ponds, the respective near-surface aquifer will be continually recharged causing leaching of the deposited mineral salts, metals, nutrients, etc. from the ponds to the Wash for many years hence.

B. Municipal/Industrial Waste Sources Other Than BMI

There were seven major sources of waste being discharged into the Las Vegas Wash in addition to the previously discussed BMI Industrial Complex. They are individually discussed in the following paragraphs. Pertinent details regarding flow rates, waste characteristics, etc. for each facility are given in Tables IX-3 and IX-4.

1. The Nevada Rock and Sand Company was discharging waste water into a tributary of the Wash as indicated in

Seepage Patterns for BMI Lower Ponds — January 1972

CROSS-HATCHED AREAS ⟶ DRY AREAS, NO WATER AT TIME OF FLIGHT ★ SEEPAGE AREAS
WHITE AREAS ⟶ CONTAINED WATER AT TIME OF FLIGHT

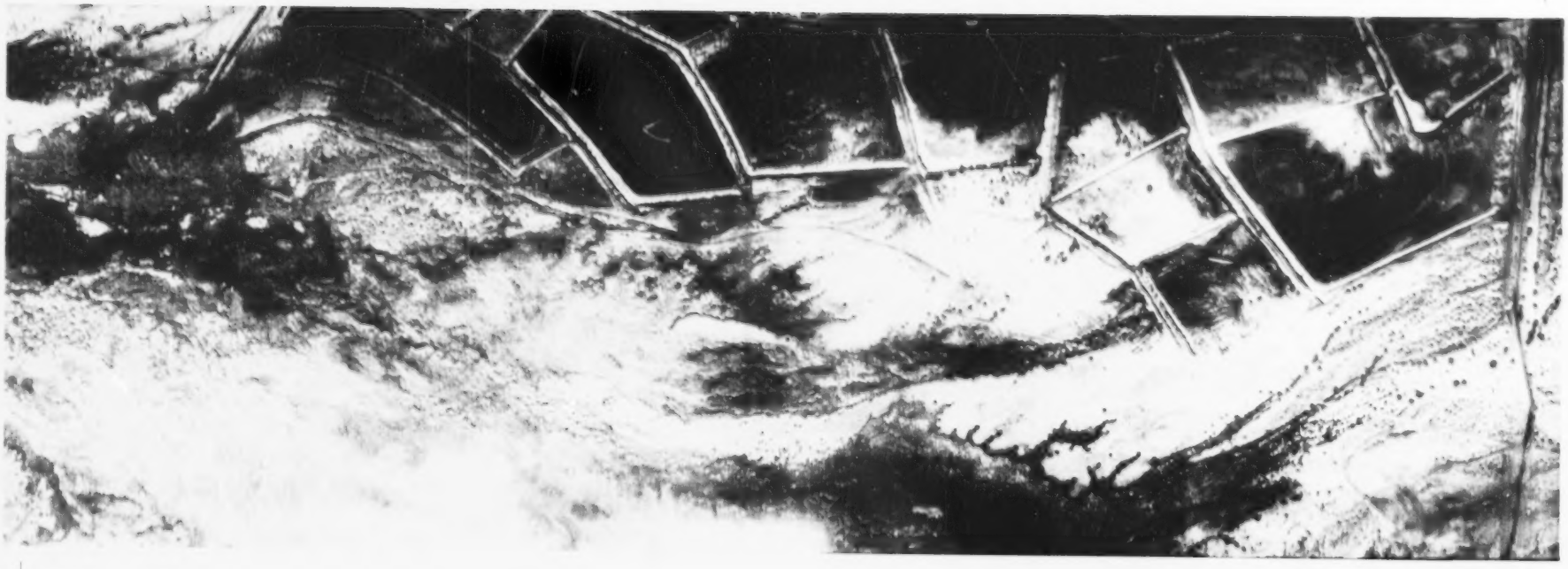


FIGURE 10

TABLE IX-3

SUMMARY OF INDUSTRIAL WASTE SOURCES DISCHARGING TO LAS VEGAS WASH[2]

Industry	Industry Type	Waste Volume mgd	Waste Type	Waste Characteristics	Treatment	Disposal	Remarks
Nevada Power Company Clark Generating Station	Electric Powerplant (SIC 491)	0.7	Cooling Tower Blowdown & Boiler Blowdown	High TDS, NO_3	None	Las Vegas Wash	
Nevada Power Company Sunrise Generating Station	Electric Powerplant (SIC 491)	0.2	Cooling Tower Blowdown & Boiler Blowdown	High TDS, NO_3	None	Las Vegas Wash	
Nevada Rock & Sand Company	Asphalt Hot Mix Plant	0.5	Scrubber Wastewater	High TDS, NO_3	Settling Pond	Las Vegas Wash	Water reuse system with no discharge planned.

TABLE IX-4

SUMMARY OF MUNICIPAL WASTE SOURCES DISCHARGING TO LAS VEGAS WASH[2]

Source	Population Served	Plant Influent mgd	Treatment Processes	Plant Effluent mgd	Effluent Disposal	Remarks
City of Las Vegas	190,000	25	Secondary (High rate Trickling Filter)	1.3	Cooling water supply for Sunrise Generating Station	Plant also serves City of North Las Vegas
				2.5	Irrigation	Influent includes 2.5 mgd bypassed by Clark County
				21	Las Vegas Wash	
Clark County Sanitation District	90,000	15-16	Secondary (High rate Trickling Filter)	2.5	Bypassed to City of Las Vegas STP for treatment	Plant also serves Nellis Air Force Base
				1.5-3.5	Cooling water supply for Clark Generating Station	
				1.4	Irrigation	
				8-10	Las Vegas Wash	

Figure 6. Above or upstream of this point, there was no water flowing in the Wash. This Company's discharge caused one of the first sustained flows in the Wash. According to another report,[2] this Company's wastewater contained significant amounts of suspended solids with a flow rate of 0.5 mgd.

2. The Nevada Power Company - Sunrise Station was discharging water into a small canal or ditch as shown in Figure 6. This ditch entered the Wash at the same location as did the tributary discussed in paragraph 1 above. This particular discharge also contributed to the beginning of sustained water flow in the Wash.
3. The City of Las Vegas sewage treatment plant is located across Vegas Valley Drive from the Sunrise Power Station. The discharge from this facility flowed through a canal to the Las Vegas Wash. This canal entered the Wash at the same location as those from the Sunrise Power Station and the Nevada Rock and Sand Company. The sewage treatment plant had a discharge rate of 21 mgd which was the major contributor to the beginning of sustained water flow in the Wash. From this point, the presence of water in the Wash was continuous to Las Vegas Bay in Lake Mead. This can be easily seen by the black areas labled the "Las Vegas Wash" in Figures 4 through 7.
4. The Clark County Sanitation District sewage treatment plant was discharging wastewater through an open ditch

directly to the Las Vegas Wash as shown in Figure 6. The influent rate from this facility into the Wash was given as 10 mgd.

5. The Nevada Power Company - Clark Station was discharging water into Duck Creek from one of three ditches originating within that facility. The position of the Station is shown in Figure 5. The amount of water in the Duck Creek Basin significantly increases from the position of this facility downstream to the Las Vegas Wash. The flow rate from this complex into the Creek was 0.7 mgd as given in Table IX-3.

6. The Stewart Bros. Gravel Pit discharges large amounts of groundwater into the Las Vegas Wash. Due to the large excavations that reach the groundwater levels, this pit would act as a major groundwater drain in this area. It can be seen in Figure 6 that the gravel pit was acting as a drain for groundwater from the BMI Upper Ponds. This water was entering the Wash and surfacing as shown in Figure 6.

7. The tailings piles of the old Manganese Mine (Item 18 of Figure 1) have been slowly leaching into the Las Vegas Wash, or more precisely, they have been entering the Wash by surface sediment transportation along with ambient aluvial materials, for an extended period of time. This is shown in Figures 4 and 7. The tailings and aluvial materials have formed a mound-of-sorts in the Wash as shown.

C. Las Vegas Wash Channel Data

The Desert Research Institute was awarded an EPA research grant to study the ground and surface water behavior in the Las Vegas Valley. The study has revealed that the actual water path or channel, through the Las Vegas Wash, was partially unknown in certain areas due to the intense foliage densities present in the Wash. The false color infrared and IRLS data provided exacting information from which the water channel has been located. The photographic prints of the high altitude IRLS data from North Las Vegas to Las Vegas Bay are given in Figures 4 and 5 for the 2 December 1971 mission and Figures 6 and 7 for the 13 January 1972 mission. The black areas within these prints were cooler than the lighter or white areas at the time of flight. It is easily seen that the dark areas extend from the Las Vegas sewage treatment plant/Sunrise Station facilities continuously downstream to Las Vegas Bay. This does indicate the presence of surface or near surface water continuously between the two above-mentioned locations. The white area in Las Vegas Bay (upper left portion of Figure 7) was due to sun reflections from the surface of the water.

In order to plot the actual water path through the Las Vegas Wash, low altitude IRLS data were obtained between the BMI Lower Ponds and Las Vegas Bay in Lake Mead. This is the most significant portion of the Wash. These data are presented in the form of black and white prints as Figures 10 through 17.

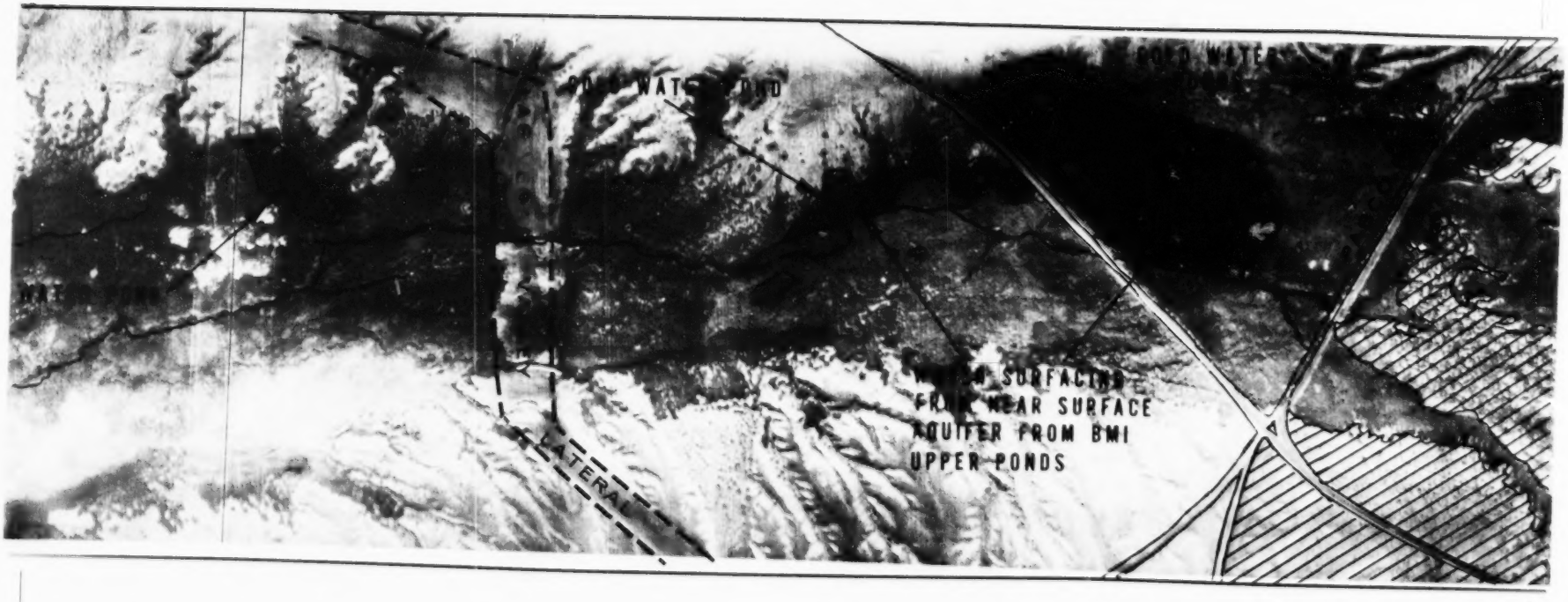


FIGURE II

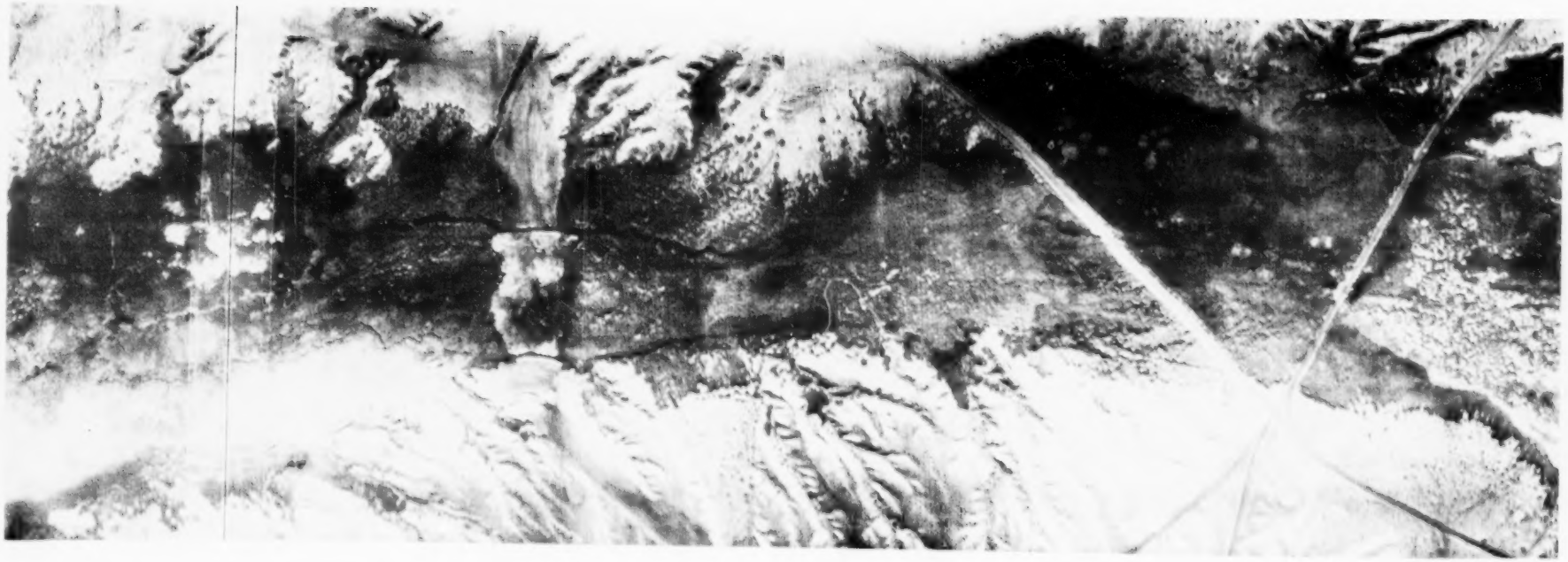


FIGURE II

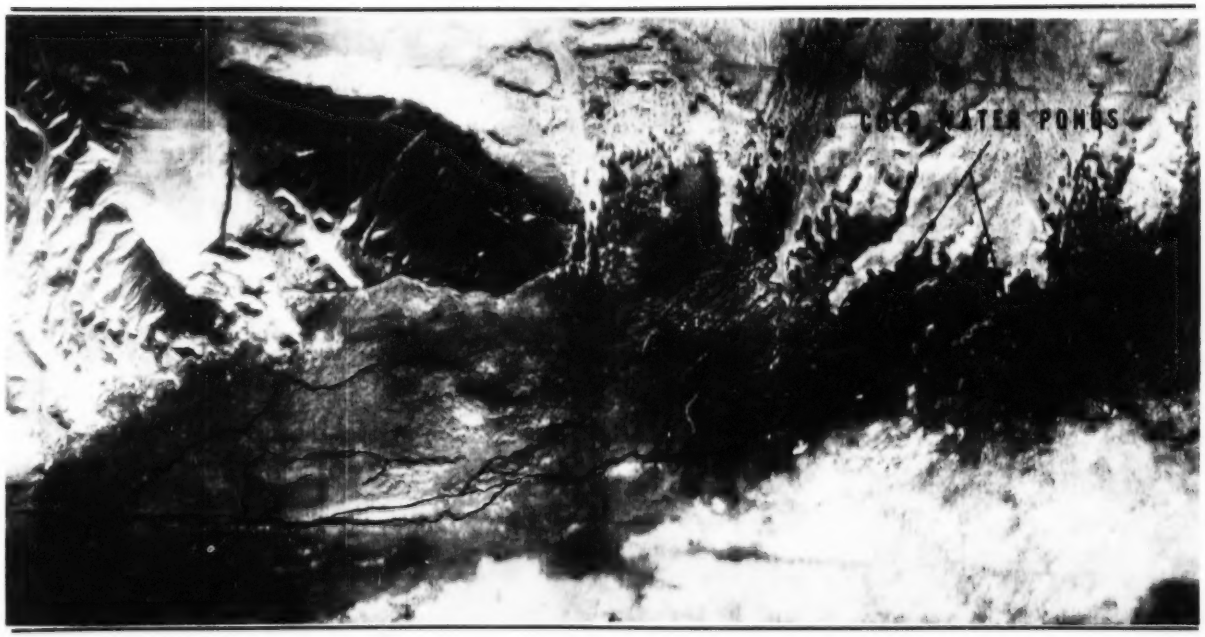


FIGURE 12

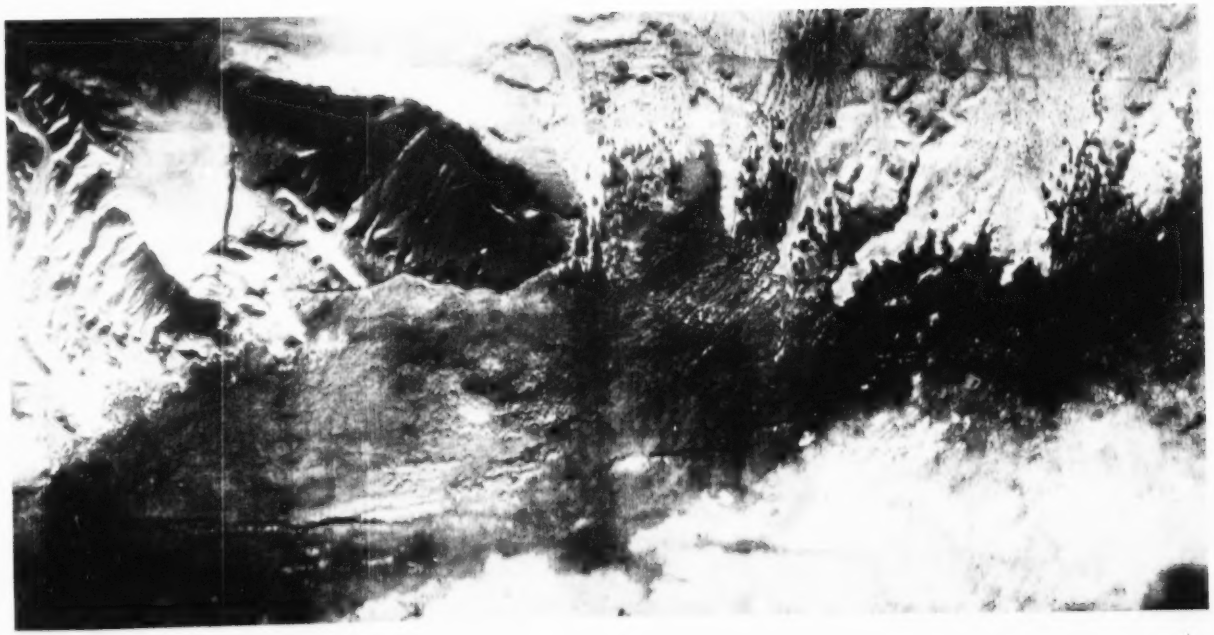


FIGURE 12

FIGURE 13

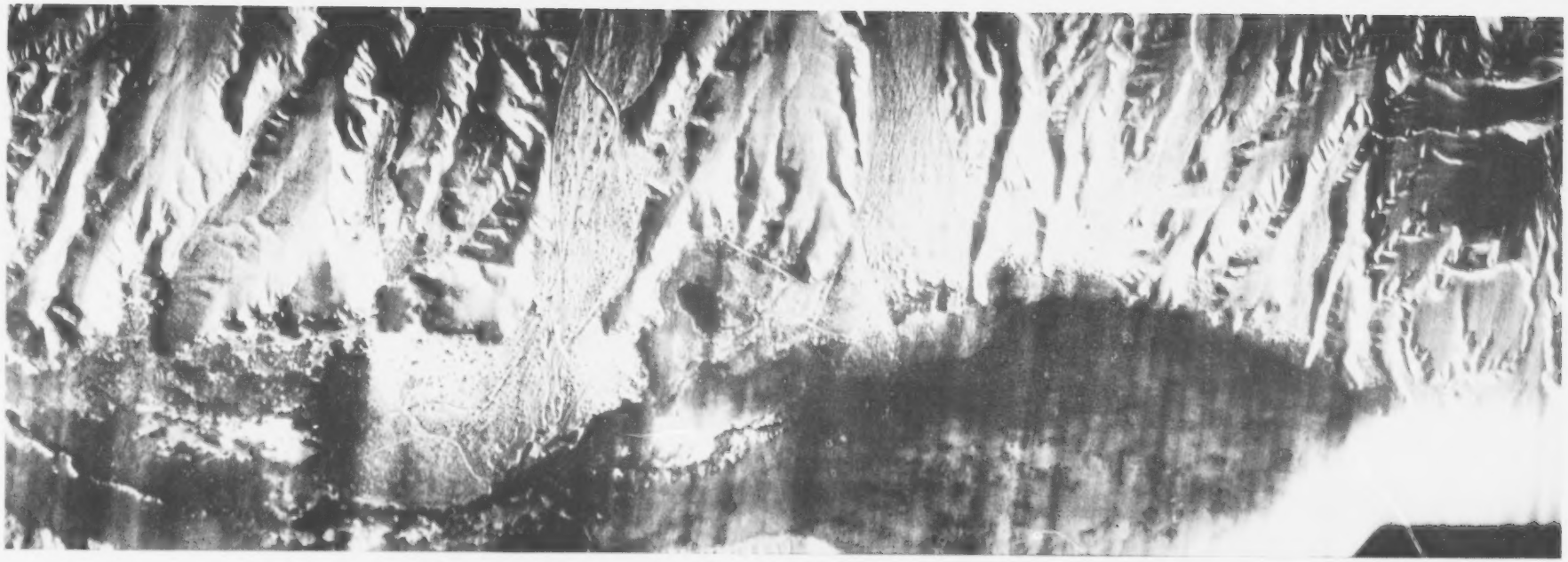


FIGURE 13

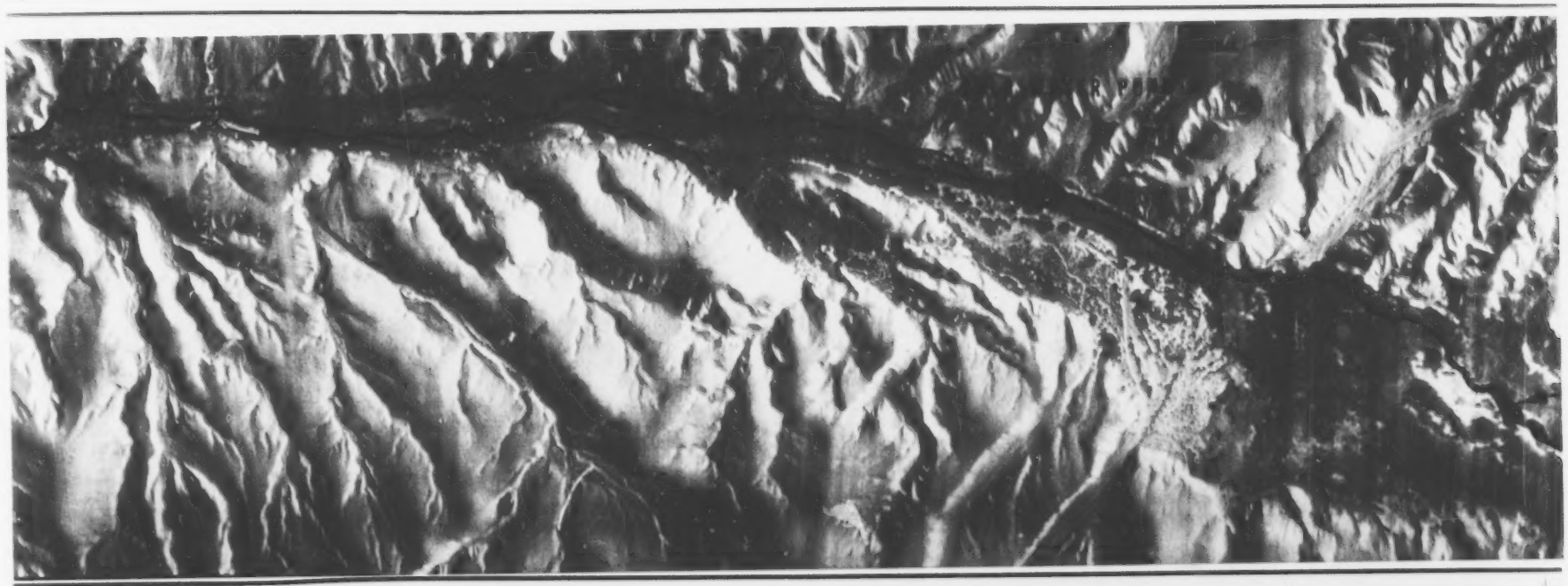


FIGURE 14

FIGURE 14

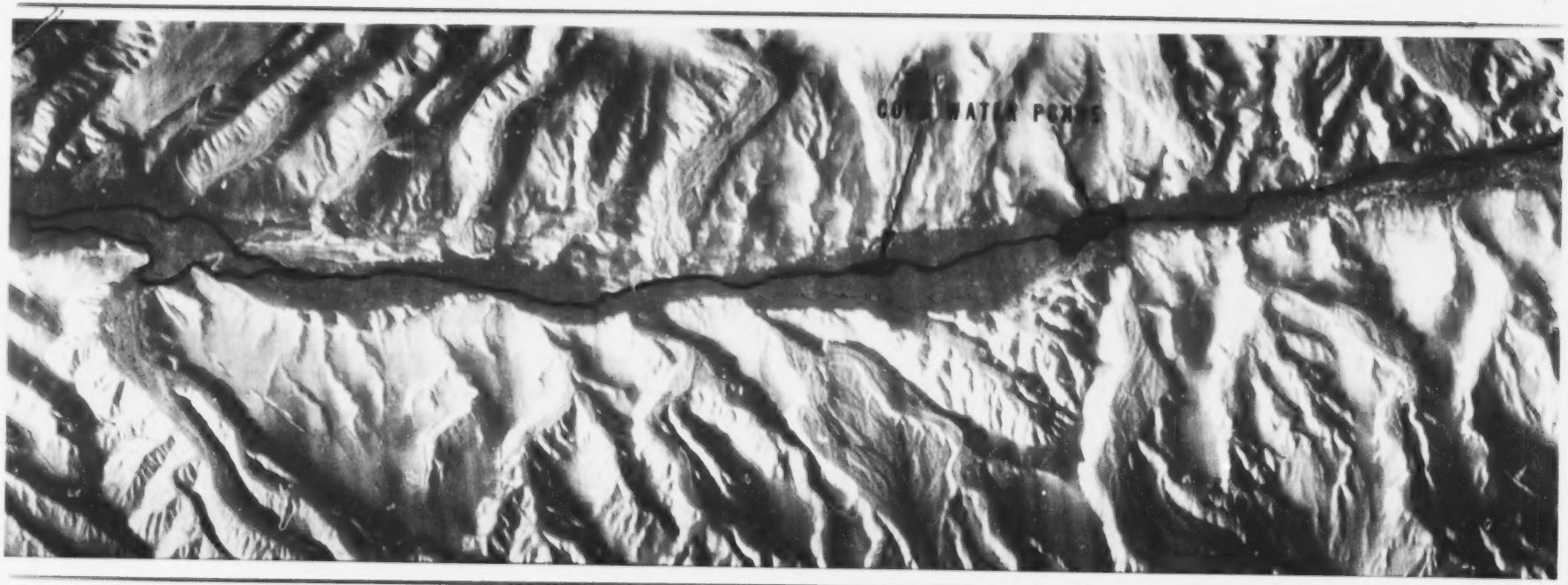


FIGURE 15

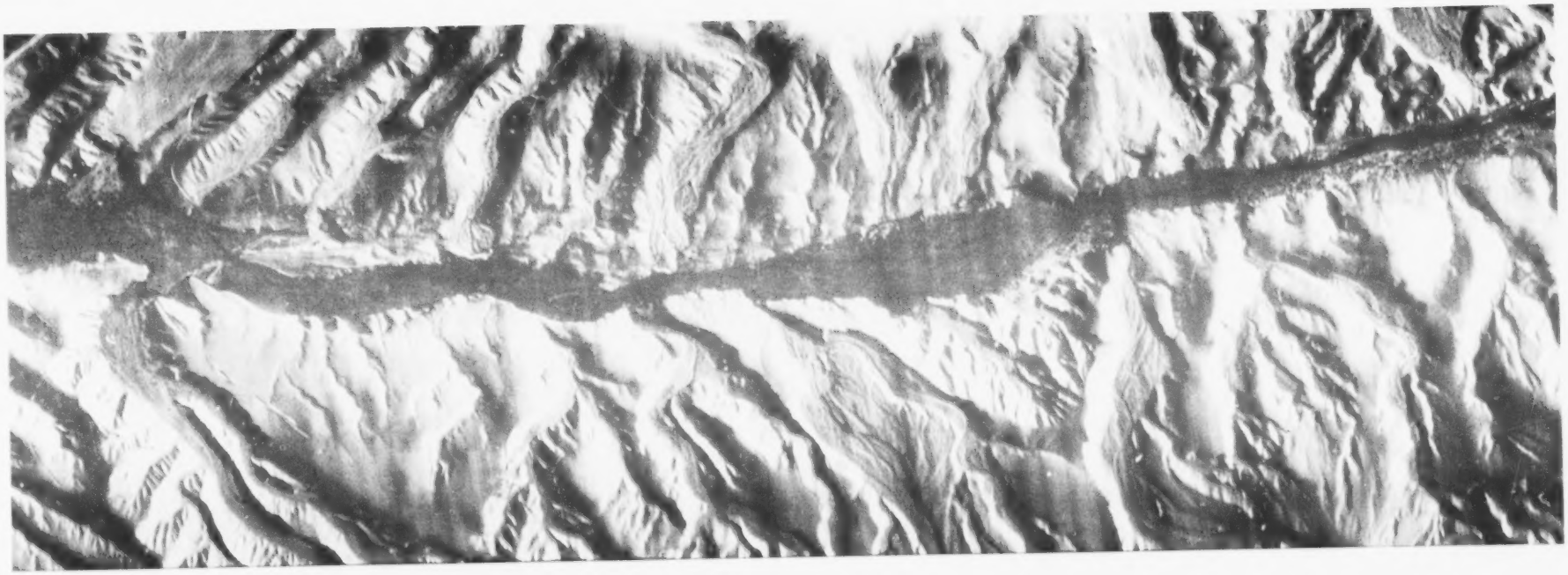


FIGURE 15

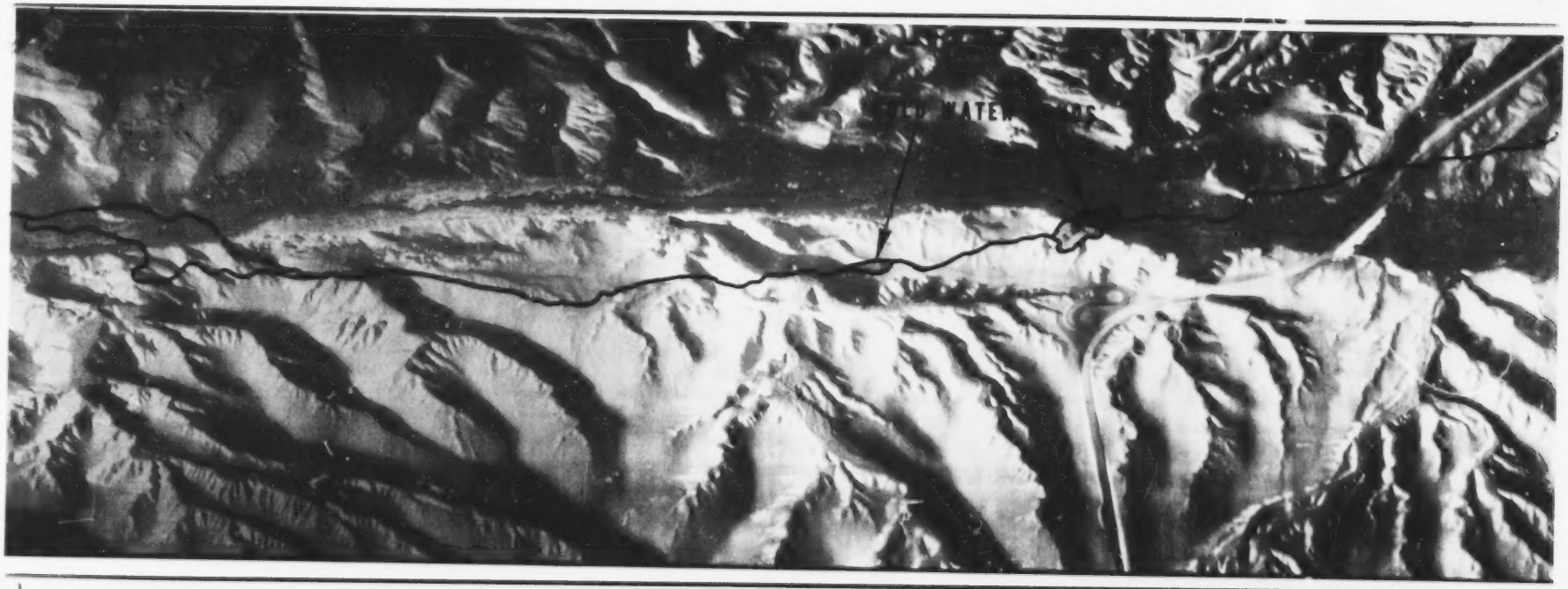


FIGURE 16

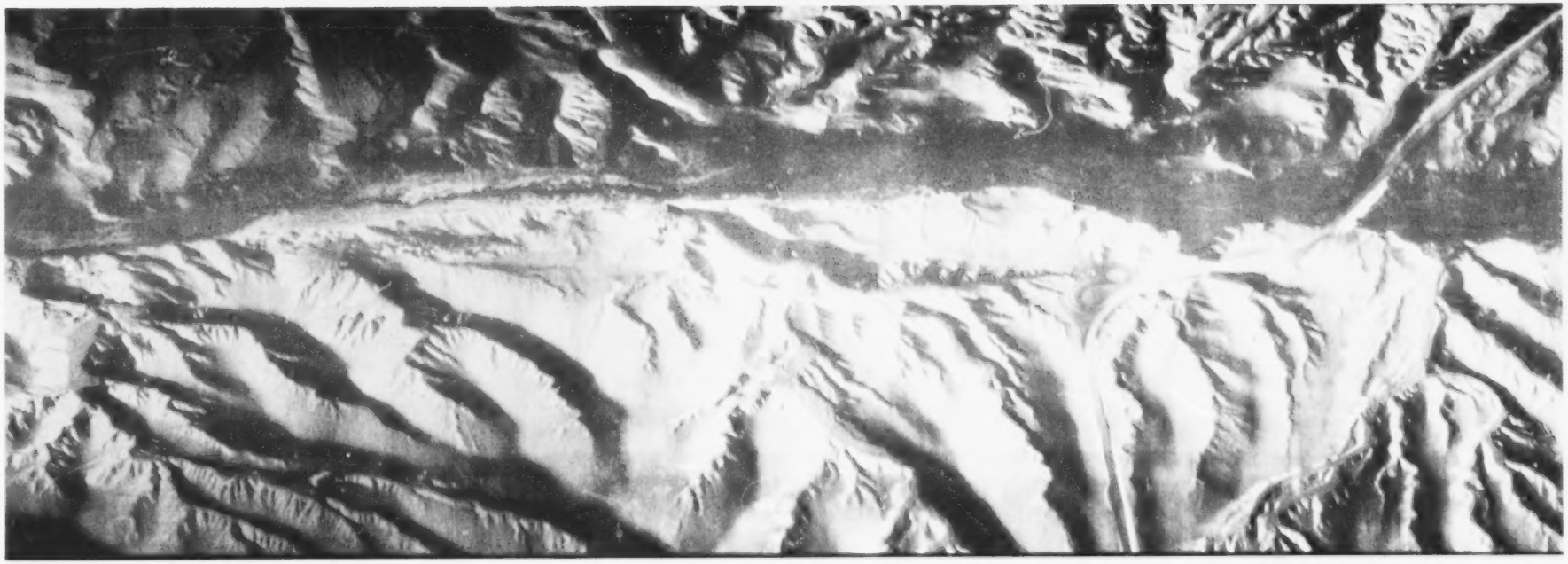


FIGURE 16

FIGURE 17

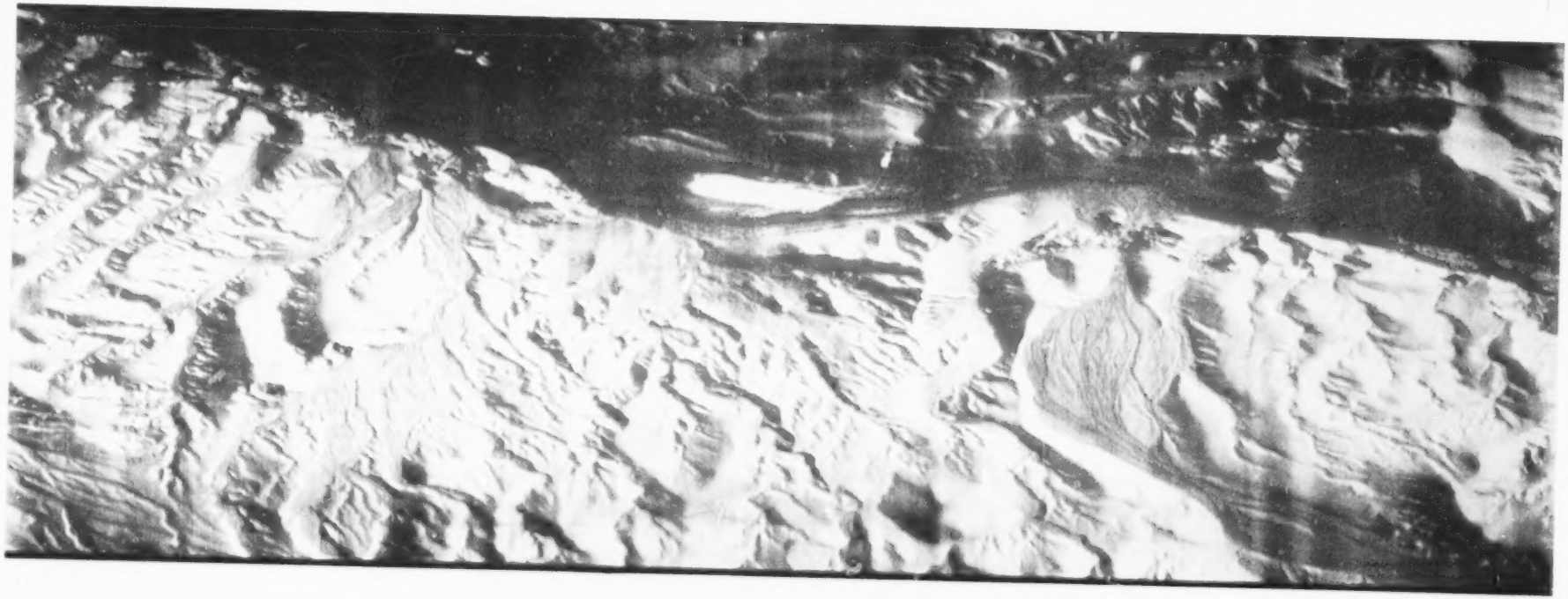


FIGURE 17

The water path through the Wash is plotted on a series of transparent overlays and positioned in this report with their respective IRLS prints. To properly align the overlays with respect to the prints, position the crosses in the upper left and lower right corners of the overlay over those on that respective print. [The vertical lines at the edge of each print designate the amount of overlap with the previous or the subsequent adjacent print. The prints can be put together to form a continuous thermal map of the Wash.] The black nonlinear lines on the transparencies indicate the water path or channel through the Wash. There is one small area, 0.54 miles long and located 2.25 miles downstream from Pabco Road and Gravel Pit Haulage Road intersection, that the aircraft missed while in the low altitude mission on 19 January 1972. This area was covered in the higher altitude missions previously discussed. The continuance of water in the Wash has been established but the precise water path could not be plotted for this short distance. The locations of groundwater surfacing ponds within the Wash Basin, etc., are indicated on the respective overlays along with respective sources.

Finally, any source that would be discharging a liquid into the Las Vegas Wash will definitely reach Las Vegas Bay and thus Lake Mead.

REFERENCES

1. Kaufmann, Robert F., Desert Research Institute, Effects of Basic Management, Incorporated, Effluent Disposal on the Hydrology and Water Quality of the Lower Las Vegas Wash Area, Las Vegas, Nevada; an interim progress report to the Environmental Protection Agency on WQO-EPA Project No. 13030 EOB, "Effect of Water Management on Quality of Ground and Surface Recharge Las Vegas Valley," November 1971.

2. Pollution Affecting Las Vegas Wash, Lake Mead and the Lower Colorado River, Nevada-Arizona-California, dated December 1971, by the Environmental Protection Agency, Office of Enforcement, Division of Field Investigations, Denver Center.